AD-A094 568 NAVAL POSTGRADUATE SCHOOL MONTEREY CA F/G 9/2

STATISTICS PROGRAMS FOR THE TI-59 CALCULATOR.(U)

DEC 80 R W STORER

UNCLASSIFIED NL

1 OF 2

AD-A094568

(2) LEVEL

NAVAL POSTGRADUATE SCHOOL

Monterey, California

THESIS

STATISTICS PROGRAMS FOR
THE TI-59 CALCULATOR

by

Richard William Storer

December 1980

Thesis Advisor: D. R. Barr

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A094 568	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Statistics Programs for the TI-59 Calculator		5. TYPE OF REPORT & PERIOD COVERED Master's Thesis; December 1980
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Richard William Storer		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Postgraduate School Monterey, California 93940		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Postgraduate School Monterey, California 93940		12. REPORT DATE December 1980
		13. NUMBER OF PAGES 135
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) Naval Postgraduate School Monterey, California 93940		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

TI-59
Hand-Held Calculator
Programmable Calculator
Confidence Interval
Hypothesis Tests
Distribution Approximations

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This paper presents a package of nine programs for the TI-59 calculator. This package was developed as a solution to two problems. One problem involved expanding and modifying an existing set of programs; and a second problem involved developing five distribution approximating programs. The solution to these problems represents a package with considerable capability in computing confidence intervals, performing

DD FORM 1473, 1 JAN 73 EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-014-6601

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

hypothesis tests and approximating distribution values. The distribution approximations include inverse CDF values for the Normal, Chi-square, Student's t and F distributions, which allow the computation of confidence intervals without using tables.

The TI-59 proved to be a useful tool in solving these problems and demonstrated the capability of hand-held programmable calculators. The comprehensive set of user guides included in this programming package provides even the inexperienced user with a step-by-step introduction to this capability. Additionally, the methods used in preparing this programming package are directly applicable to other calculators or computers.

Dist A

Approved for public release; distribution unlimited.

Statistics Programs for the TI-59 Calculator

by

Richard William Storer
Captain, United States Air Force
B.S., United States Air Force Academy, 1972

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN OPERATIONS RESEARCH

from the

NAVAL POSTGRADUATE SCHOOL
December 1980

Author Richard W Storer

Approved by: Donald R Barr
Thesis Advisor

Peter W. Zehna
Co-Advisor

Kneale T. Marshall
Chairman, Department of Operations Research

W M Woods
Dean of Information and Policy Sciences

ABSTRACT

This paper presents a package of nine programs for the TI-59 calculator. This package was developed as a solution to two problems. One problem involved expanding and modifying an existing set of programs; and a second problem involved developing five distribution approximating programs. The solution to these problems represents a package with considerable capability in computing confidence intervals, performing hypothesis tests and approximating distribution values. The distribution approximations include inverse CDF values for the Normal, Chi-square, Student's t and F distributions, which allow the computation of confidence intervals without using tables.

The TI-59 proved to be a useful tool in solving these problems and demonstrated the capability of hand-held programmable calculators. The comprehensive set of user guides included in this programming package provides even the inexperienced user with a step-by-step introduction to this capability. Additionally, the methods used in preparing this programming package are directly applicable to other calculators or computers.

TABLE OF CONTENTS

TABLE OF SYMBOLS

α	Significance level
γ	Confidence level, $(1-\alpha)$
θ	Arbitrary distribution parameter
μ	Population mean
v	Degrees of freedom
ρ	Population correlation coefficient
σ	Population standard deviation
σ^2	Population variance
χ^2	Chi-square distribution
$\chi^2_p(v)$	Chi-square p^{th} percentile with v degrees of freedom
$\boxed{}$	Symbol for calculator keystroke
a	Arbitrary constant
b	Arbitrary constant
d_i	Data point from sample of differences $x_i - y_i$
F	Symbol for F distribution
$F_p(v_1,v_2)$	F p^{th} percentile with v_1 and v_2 degrees of freedom
i	Counting index
k	Number of separate sets in multinomial distribution
l	Lower confidence bound
m	Number of data points in sample y
n	Number of data points in sample x
$N(\mu,\sigma)$	Normal distribution
p	Probability value
r	Sample correlation coefficient
R_{00}	Storage register 00 to 99

s	Sample standard deviation
s^2	Sample variance
s_d	Sample standard deviation for difference $d_i = x_i - y_i$
S	Population standard deviation
S^2	Population variance
t	Student's t distribution
$t_p(v)$	Student's t p^{th} percentile with v degrees of freedom
u	Upper confidence bound
$\bar{x}$	Sample mean for x_i's
x_i	Data point from sample x
$\bar{y}$	Sample mean for y_i's
y_i	Data point from sample y
z_p	Normal p^{th} percentile

I. INTRODUCTION

The purpose of this paper is to trace the development of a package of nine programs for use in the TI-59 calculator. Two of these programs compute confidence intervals for either the one-population or two-population situations. Another two programs perform hypothesis testing, again, for either one- or two-population situations. The remaining five programs generate approximate distribution values for the Normal, Binomial/Multinomial, Chi-square, Student's t and F distributions.

The basis for this programming effort was a set of four TI-59 programs written by Professor P. W. Zehna for his personal use and later used in the classroom. Professor Zehna's programs also computed confidence intervals and performed hypothesis testing. However, his programs were not completely user-friendly, especially in terms of user guides; and they were dependent on obtaining some percentile values from standard tables. This paper then presents a significant expansion in the scope of these early programs. The main thrust of this expansion includes a simplified and standardized set of programs and user guides, while eliminating the dependence on distribution tables.

This package of nine programs was designed for two types of users: the student, who might be asked to quickly solve several very different problems in succession; and the working analyst, whose main concern is one specific problem which

requires great accuracy. Of particular importance to both types of users is a detailed set of user guides (Appendix A) which includes sample problems. Many of these sample problems have been solved in two ways; the first way involves using program-generated percentiles; the other way requires input of tabled percentiles. While it is not absolutely necessary to look up tabled values when using the confidence interval programs, that option has been included, and should be used when increased accuracy is desired. Except for some cases involving small degrees of freedom, however, the accuracy of these first two programs is quite good as can be seen in the sample problems of Appendix A. When tables are not available, the percentile values generated by the five distributional programs is outstanding (Appendix B) and can be used in lieu of tabled values. One very convenient feature of the distribution programs is the ability to provide values normally available only by interpolation in the standard tables. It should be noted that the methods used to generate approximations in the confidence interval program is slightly less accurate than those used in the distribution programs. This difference is due to the limited number of program steps available in the first two programs. Except for the two hypothesis testing programs, there is no requirement to use the applied statistics module in the TI-59. However, this module is required when performing hypothesis testing because of the large program size and the need to provide a significance level with each test. Thus, it was possible to provide

detailed, yet simple, user guides to implement theoretically correct and accurate programs. By providing the option of using either approximations or tabled values, both the student and the analyst can accurately solve a variety of problems.

II. NATURE OF THE PROBLEM

The programming effort presented in this paper was generated by two major problems. The foremost problem involved expanding and modifying an existing set of TI-59 programs into a more user-friendly package. A second, closely related problem was adding the capability for generating accurate distribution approximations. The following discussion of the solutions to these two problems is a general overview of the particular solutions used. The specific methods and theory of solution are left for later sections in this paper.

A. USER-FRIENDLY PROGRAMMING

User-friendly programming implies programming with the user's knowledge, ability, and hardware familiarity in mind. In this light, a user-friendly program is a program which has significant capability, yet can be used by those with only a modest knowledge of either the calculator or the theory involved. Applying this definition as a framework for providing a user-friendly programming package resulted in four areas of effort. These areas are: standardized data entry, standardized solution procedures, maximized use of calculator capabilities, and improved user guides.

1. Standardized Data Entry

The nine programs in this package all require some form of data entry. The data entry schemes for the confidence interval and hypothesis testing programs need careful

standardization because of the similarity of the data and the size of the data sets involved. There are three possible types of data in these first four programs. Data may be from a one-population sample, a two-population paired sample, or a two-population independent sample. Any of these data can be easily entered in the form of summary statistics, if available; however, raw data requires some standardization between programs. The data entry schemes of the first four programs use similar data entry subroutines which take advantage of the TI-59's data entry sequence. In each of these programs, the data entry subroutine is initiated by pressing [D]. The sequence of data entry then differs slightly depending on the type of data being entered. All of these entry subroutines use a format which requires a [R/S] to be pressed after each data point entry. This method saves one keystroke for each data point compared to the TI-59's two-keystroke, [2nd] [Σ+], entry method. Also, the [R/S] key is very close to the numerical keyboard, compared to the [2nd] key, thereby eliminating a source of data entry errors that frequently occur when using the [2nd] [Σ+] sequence.

The data entry schemes used for the five distribution programs presented no standardization problem. All of these programs, except the Multinomial, require only a few parameter entries. In the Multinomial program, which can accept as many as 35 pairs of parameters, the data entry problem was more difficult. Each of the multinomial data points is stored separately until computation begins. The data entry

sequence automatically repartitions the calculator to make room for this potentially large amount of data.

Data stored directly in registers has been somewhat standardized between programs by using the same registers, where possible, for similar data. More information concerning the contents of data storage registers can be found in Appendix A.

2. <u>Standardized Solution Procedures</u>

A considerable effort was made to standardize the steps required in each problem solution sequence. In the two confidence interval programs (see Appendix A) problems are solved in three steps. In the first step, the calculator is repartitioned and the data are entered. The second step requires entry of either a percentage, in which case the program generates an approximate percentile, or a previously obtained percentile value. The last step involves the selection and initiation of the proper solution subroutine. A similar three-step sequence is used in the two hypothesis testing programs where the first step includes repartitioning and entry of test parameters. The second step involves data entry, and the third step, subroutine initiation.

The five distribution programs contain only a limited amount of standardization due to the different nature of the programs. The Normal, Chi-square, Student's t, and F programs use the $\boxed{A}$, $\boxed{B}$, $\boxed{C}$ labels for the same basic functions. The $\boxed{A}$ label is used in the Normal, Chi-square, and Student's t (not F) to generate approximate density values. The $\boxed{B}$ label

is used to generate CDF approximations in all four of these programs, where similarly, the $\boxed{C}$ label is used to generate inverse CDF approximations. The Binomial/Multinomial program shares none of these standardized label uses.

3. Maximized Use of Calculator Capabilities

The ability of the TI-59 to repartition was the basis for the expansion in capability over that achieved by Professor Zehna's original programs. Repartitioning allows the addition of the program steps necessary for the inverse CDF approximating subroutines in the confidence interval programs. The added programming space was also used to compute one confidence interval estimate, for σ^2 with μ known, which was not available in the original programs. Additionally, repartitioning makes possible an F distribution program and a Multinomial distribution program.

However, repartitioning is not without its price. The larger programs now require three edges of the magnetic program cards, which presents a slight inconvenience in added loading and storage requirements. Other problems associated with repartitioning, such as inadvertent loss of program steps and unwanted or improper partitioning, have hopefully been eliminated from this programming package by extensive validation with sample problems.

4. Improved User Guides

Preparation of improved user guides was a key element in making a user-friendly programming package. The complexity of the programs involved and the intended use by students

necessitated a departure from the standard TI-59 program record sheet. As can be seen in Appendix A, the improved user guides are organized with the user in mind. The general outline for each user guide follows this pattern:

a. Introduction

b. General Procedures

c. Specific Procedures

d. Additional Capabilities

e. Labels Used

f. Storage Register Contents

g. Sample Problems

The user guides for the five distrubiton programs have been combined to take advantage of the relative simplicity in using these programs. The answers to each sample problems are in a 10-digit format to provide a positive check on calculator output when working each problem. The confidence interval sample problems are solved in two ways to demonstrate the differences between using approximations and tabled values for the required percentiles.

B. ACCURATE DISTRIBUTION APPROXIMATIONS

The second major problem addressed in this section involves generating distribution approximations for both the confidence interval programs and the distribution programs. The capability to compute accurate distribution approximations provides a new dimension to this programming package by eliminating the need for standard distribution tables when

solving confidence interval problems. A drawback of this new capability is the time required to obtain some values from the approximating programs. The time required by the confidence interval approximations is not nearly as long as that for the distribution programs; but then, the quality of the approximations is not as good either (see Section III).

Appendix B contains comparisons of tabled values with both the confidence interval program approximations (Type I) and the distribution program approximations (Type II). The actual probability values used in these comparisons were obtained using the distribution programs and can be regarded as being very close to the actual probability achieved. The missing values in the inverse F comparison are due to the inability of the Type I approximation to generate inverse F values when either of the degrees of freedom parameters is one. Also, while only selected approximations are listed in the comparison, the inverse CDF approximations are of nearly equal quality over the entire range of the appropriate function. The Type I approximations displayed in Appendix B are generally not as accurate as Type II approximations in terms of actual probability achieved. Only the inverse CDF approximations for the Chi-square, t, and F distributions are presented in Appendix B since all the other approximations which are available in the distribution programs duplicate table entries. These other approximations include probability values, CDF values, and various other distribution values (see Appendix A). The superior quality of these approximations

can be attributed to using the same approximating methods used in the TI-59 Applied Statistics Module (see Section III).

III. THEORY

This section on theory is presented as a background for the solution methods used in the accompanying programs. As such, it is not intended to be a primer in statistics. Instead, this section should be considered as an intermediate level derivation of the specific statistical methods used in programming. For a more basic explanation of this material, the references cited within each subject area, or equivalent texts, should be consulted.

There are five subject areas discussed in this section. First, the theory used for estimating confidence intervals in the first two programs is discussed. Next, the hypothesis testing theory necessary for programs three and four is discussed. And lastly, the methods used in all nine programs to obtain approximations to distribution values are discussed.

A. THEORY FOR ONE-POPULATION CONFIDENCE INTERVAL ESTIMATION

The derivation of theoretical interval estimates will be done in the same order as these estimates appear in the User Guide for Program 1 (Appendix A). Most of these derivations use the pivotal-qualtity method to obtain confidence intervals (1,u) [Ref. 1: pp. 379-389]. Other methods used here will be discussed in slightly more detail, but will still be brief compared to the referenced texts. When forming a C.I. with a nonsymmetric distribution the interval will represent an equal tails solution, where equal tails implies

$P[X < l] = P[X > u] = (1-\gamma)/2$. This method does not provide the shortest C.I. for a given γ; however, this method is commonly used for its ease of computation [Ref. 1: p. 382]. Regardless of the method used, the resulting C.I. given in this section by (l,u) represents the formula used to calculate interval estimates.

1. C.I. for Normal μ with σ^2 Known [Ref. 2: pp. 77-80]

Assuming that X is distributed $N(\mu, \sigma^2)$ and using $(\bar{X}-\mu)/(\sigma/\sqrt{n})$ as the pivotal-quantity, a $100\gamma\%$ C.I. is constructed thus:

$$P\left[z_{(1-\gamma)/2} < (\bar{X}-\mu)/(\sigma/\sqrt{n}) < z_{(1+\gamma)/2}\right] = \gamma.$$

Substituting $z = z_{(1+\gamma)/2} = -z_{(1-\gamma)/2}$ and simplifying we have:

$$P\left[\bar{X} - z\sigma/\sqrt{n} < \mu < \bar{X} + z\sigma/\sqrt{n}\right] = \gamma, \text{ or}$$

$$(l,u) = (\bar{x} - z\sigma/\sqrt{n}\ ,\ \bar{x} + z\sigma/\sqrt{n}).$$

2. C.I. for Normal μ with σ^2 Unknown [Ref. 2: p. 80; Ref. 3: p. 277; Ref. 1: p. 381]

Assuming X is distributed $N(\mu, \sigma^2)$ and using $(\bar{X}-\mu)/(s/\sqrt{n})$, which is distributed $t(n-1)$, as the pivotal-quantity, a $100\gamma\%$ C.I. is constructed thus:

$$P\left[t_{(1-\gamma)/2}(n-1) < (\bar{X}-\mu)/(s/\sqrt{n}) < t_{(1+\gamma)/2}\right] = \gamma.$$

Substituting $t = t_{(1+\gamma)/2}(n-1) = -t_{(1-\gamma)/2}(n-1)$ and simplifying we have:

$$P\left[\bar{X} - ts/\sqrt{n} < \mu < \bar{X} + ts/\sqrt{n}\right] = \gamma \text{, or}$$

$$(l,u) = (\bar{x} - ts/\sqrt{n}\ ,\ \bar{x} + ts/\sqrt{n}).$$

3. <u>C.I. for Bernoulli p</u> [Ref. 4: pp. 376-381]

The pivotal-quantity method does not work for the Bernoulli case and another method will be briefly developed here. This method starts with two numbers a and b such that

$$P\left[a < \bar{X} < b\right] = \gamma .$$

From these limits we have:

$$P\left[\bar{X} \leq a\right] = (1-\gamma)/2 = P\left[\bar{X} \geq b\right] \text{ , or equivalently,}$$

$$P\left[\sum X_i \leq na\right] = (1-\gamma)/2 = P\left[\sum X_i \geq nb\right] .$$

Now $\sum X_i$ is distributed Binomial (n,p) which, for k < n, can be explicitly related to the incomplete Beta function and hence to the F distribution to yield:

$$u = \frac{(n\bar{X} + 1)F_{(1+\gamma)/2}(v_1, v_2)}{(n - n\bar{X}) + (n\bar{X} + 1)F_{(1+\gamma)/2}(v_1, v_2)}$$

$$l = \frac{n\bar{X}}{(n\bar{X} + (n - n\bar{X} + 1)F_{(1+\gamma)/2}(v_2+2, v_1-2)}$$

where $v_1 = (2n\bar{X} + 2)$, and $v_2 = (2n - 2n\bar{X})$

l and u form a $100\gamma\%$ conservative random interval thus:

$$P\left[l < p < u\right] \geq \gamma.$$

The outcome (l,u) is a conservative C.I. in the sense that for this discrete distribution the confidence that (l,u) contains p is at least $100\gamma\%$.

4. <u>C.I. for Normal σ^2 with μ Known</u> [Ref. 3: p. 275]

Assuming that X is distributed $N(\mu, \sigma^2)$ and using $\sum((X_i - \mu)/\sigma)^2$, which is distributed $\chi^2(n)$, as the pivotal-quantity, a $100\gamma\%$ equal tails C.I. is constructed thus:

$$P\left[\chi^2_{(1-\gamma)/2}(n) < \sum(X_i - \mu)^2/\sigma^2 < \chi^2_{(1+\gamma)/2}(n)\right] = \gamma$$

Substituting $q_1 = \chi^2_{(1-\gamma)/2}(n)$, and $q_2 = \chi^2_{(1+\gamma)/2}(n)$ and simplifying we have:

$$P\left[\sum(X_i - \mu)^2/q_2 < \sigma^2 < \sum(X_i - \mu)^2/q_1\right] = \gamma, \text{ or}$$

$$(l,u) = (\sum x_i^2 - n\mu^2)(1/q_2\ ,\ 1/q_1).$$

5. <u>C.I. for Normal σ^2 with μ Unknown</u> [Ref. 1: p. 382; Ref. 3: p. 277]

Assuming that X is distributed $N(\mu, \sigma^2)$ and using $(n-1)s^2/\sigma^2$, which is distributed $\chi^2(n-1)$, as the pivotal-quantity, a $100\gamma\%$ equal tails C.I. is constructed thus:

$$P\left[\chi^2_{(1-\gamma)/2}(n-1) < (n-1)s^2/\sigma^2 < \chi^2_{(1+\gamma)/2}(n-1)\right] = \gamma.$$

Substituting $q_1 = \chi^2_{(1-\gamma)/2}(n-1)$, and $q_2 = \chi^2_{(1+\gamma)/2}(n-1)$ and simplifying we have:

$$P\left[(n-1)s^2/q_2 < \sigma^2 < (n-1)s^2/q_1\right] = \gamma, \text{ or}$$

$$(1,u) = (n-1)s^2(1/q_2\ ,\ 1/q_1).$$

6. <u>C.I. for Exponential λ or μ</u> [Ref. 3: p. 279]

Assuming that $X_1, X_2, \ldots X_n$ are exponential random variables with parameter λ and using $2\lambda n\bar{X}$, which is distributed $\chi^2(2n)$, as the pivotal-quantity, a 100γ% equal tails C.I. is constructed thus:

$$P\left[\chi^2_{(1-\gamma)/2}(2n)/2n\bar{X} < 2\lambda n\bar{X} < \chi^2_{(1+\gamma)/2}(2n)\right] = \gamma.$$

Simplifying we have:

$$P\left[\chi^2_{(1-\gamma)/2}(2n)/2n\bar{X} < \lambda < \chi^2_{(1+\gamma)/2}(2n)/2n\bar{X}\right] = \gamma, \text{ or}$$

$$(1,u) = (\chi^2_{(1-\gamma)/2}(2n)/2n\bar{x}\ ,\ \chi^2_{(1+\gamma)/2}(2n)/2n\bar{x}).$$

The C.I. for the mean time to failure ($\mu = 1/\lambda$) is constructed by inverting the above interval to yield:

$$(1,u) = (2n\bar{x}/\chi^2_{(1+\gamma)/2}(2n)\ ,\ 2n\bar{x}/\chi^2_{(1-\gamma)/2}(2n))$$

[Ref. 4: p. 382].

B. THEORY FOR TWO-POPULATION CONFIDENCE INTERVAL ESTIMATION

The confidence interval estimates for two-population situations are discussed here in the same order as they appear in the User Guide for Program 2 (Appendix A). All of these estimates use the pivotal-quantity method discussed earlier [Ref. 1: pp. 379-389]. As in the one-population case above, the C.I. given by (l,u) represents the formula used to calculate the interval estimate.

1. C.I. For Bernoulli p_X-p_Y for Large m and n [Ref. 2: p. 249]

Large m and n means np_X, mp_Y, $n(1-p_X)$, and $m(1-p_Y)$ all greater than five. With this condition met and assuming that X and Y are independent and normally distributed,

$$\frac{(\bar{X} - \bar{Y}) - (p_X - p_Y)}{\sqrt{s_X{}^2/n + s_Y{}^2/m}} ,$$

which is distributed approximately N(0,1), is used as the pivotal-quantity. A $100\gamma\%$ C.I. is constructed thus:

$$P\left[-z_{(1+\gamma)/2} < \frac{(\bar{X} - \bar{Y}) - (p_X - p_Y)}{\sqrt{\bar{X}(1-\bar{X})/n + \bar{Y}(1-\bar{Y})/m}} < z_{(1+\gamma)/2}\right] = \gamma .$$

Substituting $c = \sqrt{\bar{X}(1-\bar{X})/n + \bar{Y}(1-\bar{Y})/m}$, and simplifying yields:

$$P\left[\bar{X} - \bar{Y} - cz_{(1+\gamma)/2} < p_X - p_Y < \bar{X} - \bar{Y} + cz_{(1+\gamma)/2}\right] = \gamma, \text{ or}$$

$(l,u) = (\bar{x} - \bar{y} - cz_{(1+\gamma)/2}\ ,\ \bar{x} - \bar{y} + cz_{(1+\gamma)/2})$.

2. C.I. for Normal $\mu_X - \mu_Y$ for X and Y Paired [Ref. 2: p. 123]

Assuming that X and Y are normally distributed and letting $\bar{D} = \bar{X} - \bar{Y}$, and using $(\bar{D} - \mu_D)/(S_D/\sqrt{n})$, which is distributed t(n-1), as the pivotal-quantity, a 100γ% C.I. is constructed thus:

$$P\left[t_{(1-\gamma)/2}(n-1) < (\bar{D} - \mu_D)/S_D/\sqrt{n}) < t_{(1+\gamma)/2}(n-1)\right] = \gamma.$$

Substituting $\mu_D = \mu_X - \mu_Y$, and $t = t_{(1+\gamma)/2}(n-1) = -t_{(1-\gamma)/2}(n-1)$ and simplifying yields:

$$P\left[\bar{D} - tS_D/\sqrt{n} < \mu_X - \mu_Y < \bar{D} + tS_D/\sqrt{n}\right] = \gamma \qquad \text{, or}$$

$$(l,u) = (\bar{d} - ts_D/\sqrt{n}, \bar{d} + ts_D/\sqrt{n}),\ \text{where } s_D = \frac{\sum d_i{}^2 - (\sum d_i)^2/n}{(n-1)}$$

and $d_i = x_i - y_i$.

3. C.I. for Normal $\mu_X - \mu_Y$ with $\sigma_X{}^2 = \sigma_Y{}^2 = \sigma^2$ [Ref. 2: p. 123]

Assuming that X and Y are independent and using

$$\frac{(\bar{X} - \bar{Y}) - (\mu_X - \mu_Y)}{(1/m + 1/n)S_p^2}$$, which is distributed $t(m+n-2)$,

as the pivotal-quantity. Here and elsewhere in this paper, n and m represent the number of data points in X and Y, respectively. A $100\gamma\%$ C.I. is constructed thus:

$$P\left[t_{(1-\gamma)/2}(m+n-2) < \frac{(\bar{X}-\bar{Y}) - (\mu_X-\mu_Y)}{(1/m + 1/n)S_p^2} < t_{(1+\gamma)/2}(m+n-2)\right] = \gamma.$$

Substituting $t = t_{(1+\gamma)/2}(m+n-2) = -t_{(1-\gamma)/2}(m+n-2)$ and simplifying yields:

$$P\left[\bar{X} - \bar{Y} - t\sqrt{(1/m + 1/n)S_p^2} < \mu_X - \mu_Y < \bar{X} - \bar{Y} + t\sqrt{(1/m + 1/n)S_p^2}\right] = \gamma,$$

or $(l,u) = (\bar{x} - \bar{y} - t\sqrt{(1/m + 1/n)s_p^2}\ ,\ \bar{x} - \bar{y} + t\sqrt{(1/m + 1/n)s_p^2})$,

$$\text{where } s_p^2 = \frac{\sum(x_i - \bar{x})^2 + \sum(y_i - \bar{y})^2}{(m + n - 2)}.$$

4. <u>C.I. for Normal $\mu_X - \mu_Y$ with σ_X^2 and σ_Y^2 Known</u>

[Ref. 2: p. 123]

Assuming X and Y are independent and using

$$\frac{(\bar{X} - \bar{Y}) - (\mu_X - \mu_Y)}{\sqrt{\sigma_X^2/n + \sigma_Y^2/m}}$$, which is distributed $N(0,1)$, as

the pivotal-quantity, a $100\gamma\%$ C.I. is constructed thus:

$$P\left[-z_{(1+\gamma)/2} < \frac{(\bar{X}-\bar{Y})-(\mu_X-\mu_Y)}{\sqrt{\sigma_X^2/n+\sigma_Y^2/m}} < z_{(1+\gamma)/2}\right] = \gamma.$$

Substituting $z = z_{(1+\gamma)/2} = -z_{(1-\gamma)/2}$ and simplifying we have:

$$P\left[\bar{X}-\bar{Y}-z\sqrt{\sigma_X^2/n+\sigma_Y^2/m} < \mu_X-\mu_Y < \bar{X}-\bar{Y}+z\sqrt{\sigma_X^2/n+\sigma_Y^2/m}\right] = \gamma,$$

or $(l,u) = (\bar{x}-\bar{y}-z\sqrt{\sigma_X^2/n+\sigma_Y^2/m},\ \bar{x}-\bar{y}+z\sqrt{\sigma_X^2/n+\sigma_Y^2/m})$.

5. C.I. for Normal σ_X^2/σ_Y^2 [Ref. 4: p. 464]

Assuming X and Y are independent and using $(S_Y^2/\sigma_Y^2)/(S_X^2/\sigma_X^2)$, which is distributed $F(m-1,n-1)$, as the pivotal-quantity, a $100\gamma\%$ C.I. is constructed thus:

$$P\left[F_{(1-\gamma)/2}(m-1,n-1) < \frac{S_Y^2/\sigma_Y^2}{S_X^2/\sigma_X^2} < F_{(1+\gamma)/2}(m-1,n-1)\right] = \gamma.$$

Substituting $F_{(1-\gamma)/2}(m-1,n-1) = \dfrac{1}{F_{(1+\gamma)/2}(n-1,m-1)}$, and simplifying we have:

$$P\left[\frac{S_X^2/S_Y^2}{F_{(1+\gamma)/2}(n-1,m-1)} < \frac{\sigma_X^2}{\sigma_Y^2} < (S_X^2/S_Y^2)F_{(1+\gamma)/2}(m-1,n-1)\right] = \gamma.$$

$$\text{or } (l,u) = \left(\frac{s_X^2/s_Y^2}{F_{(1+\gamma)/2}(n-1,m-1)},\ (s_X^2/s_Y^2)F_{(1+\gamma)/2}(m-1,n-1)\right).$$

6. C.I. for Exponential $\lambda_X/\lambda_Y = \mu_Y/\mu_X$ [Ref. 4: p. 466]

Assuming X and Y are independent and using $\bar{X}\lambda_X/\bar{Y}\lambda_Y$, which is distributed F(2n,2m), as the pivotal-quantity, a 100γ% C.I. is constructed thus:

$$P\left[F_{(1-\gamma)/2}(2n,2m) < \bar{X}\lambda_X/\bar{Y}\lambda_Y < F_{(1+\gamma)/2}(2n,2m)\right] = \gamma.$$

Simplifying we have:

$$P\left[(\bar{Y}/\bar{X})F_{(1-\gamma)/2}(2n,2m) < \lambda_X/\lambda_Y < (\bar{Y}/\bar{X})F_{(1+\gamma)/2}(2n,2m)\right] = \gamma.$$

$$\text{or } (l,u) = \left((\bar{Y}/\bar{X})F_{(1-\gamma)/2}(2n,2m),\ (\bar{Y}/\bar{X})F_{(1+\gamma)/2}(2n,2m)\right).$$

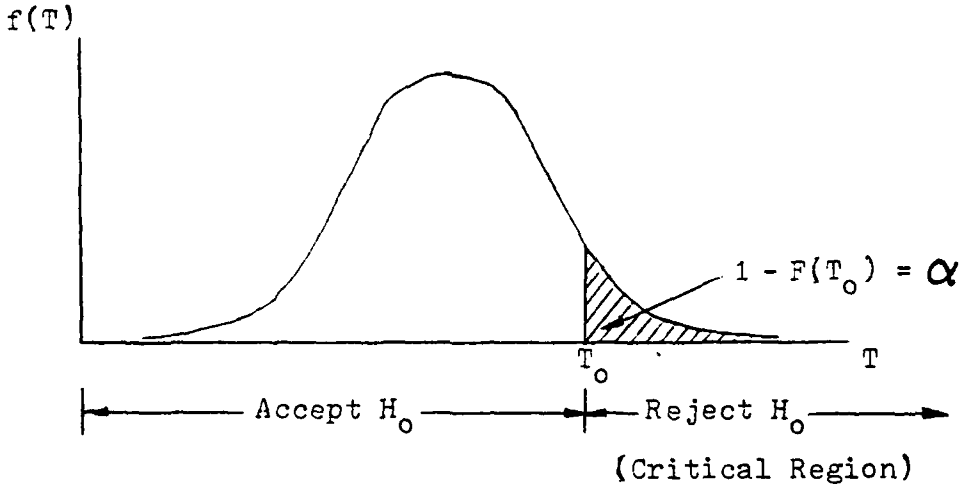
C. THEORY FOR ONE-POPULATION HYPOTHESIS TESTS

Three types of hypothesis tests are performed in Program 3; these are upper-tailed, lower-tailed and two-tailed tests. The general procedure used for all three tests is the same. Basically, a test statistic T, which has an assumed distribution, is computed with user-supplied data and then compared to a critical region defined by T_o. This T_o value is determined by the type of test, the assumed distribution, and the user-supplied α value. For two-tailed tests there are actually two values of T_o used; these values will be denoted

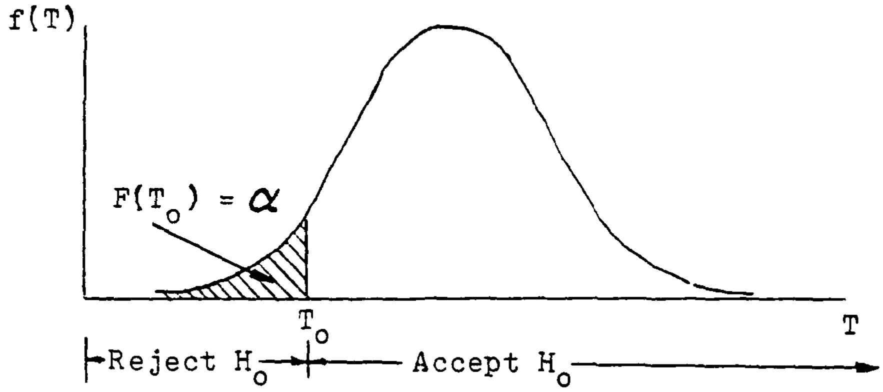
here by T_1 and T_2. In performing the test then, if the test statistic T is outside the critical region, then we accept our original hypothesis H_o; otherwise, we reject H_o and accept the alternative H_1.

The following graphs illustrate the three types of tests discussed. These graphs represent a probability density function, f(T), where the shaded area under each curve represents values from a corresponding cumulative distribution function, F(T).

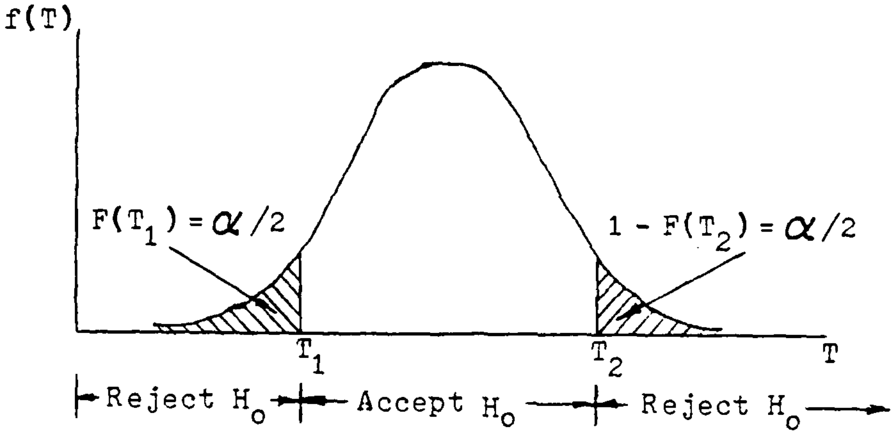
Upper-Tailed Test



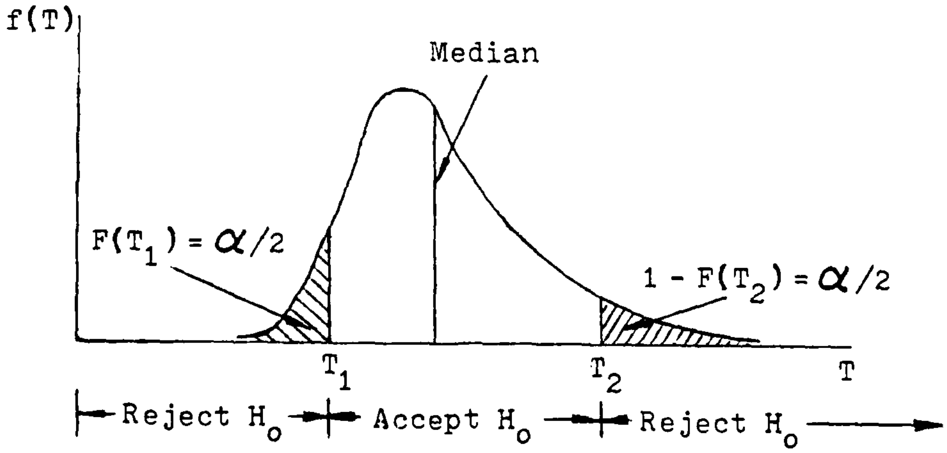
Lower-Tailed Test



Two-Tailed Test for Symmetric Distributions (Normal, t)



Two-Tailed Test for Unsymmetric Distributions (Chi-Square, F)



An upper-tailed test is performed whenever the user enters a +1, choosing the upper-tail alternate hypothesis, during step one of the solution. A lower-tailed test requires the user to enter a -1 during the solution, and a two-tailed test requires a 0 entry. For two-tailed unsymmetric tests the relationship between the test statistic and the median determines which tail is actually used for the test. If the test statistic is greater than the median then the two-tailed test is performed using the upper tail T_o value. For test statistic values less than the median the test uses the lower tail T_o value. However, there is no general agreement that a two-tailed test should be performed this way.

The test statistics used in Program 3 will now be listed in the same order in which they appear in the User Guide. This listing will also include a reference where more information concerning a particular subject can be found. Additionally, the assumed distribution for each test statistic will appear with that test statistic.

1. <u>Test Statistic for Normal μ_o with σ^2 Known</u> [Ref. 1: p. 431]

$$T = \frac{(\bar{x} - \mu_o)\sqrt{n}}{\sigma} \qquad \text{, using } N(0,1)$$

2. <u>Test Statistic for Normal μ_o with σ^2 Unknown</u> [Ref. 1: p. 431]

$$T = \frac{(\bar{x} - \mu_o)\sqrt{n}}{s_X}, \qquad \text{using } N(0,1) \text{ for } n > 30, \text{ and } t(n-1) \text{ for } n < 30$$

3. Test Statistic for Bernoulli P_o [Ref. 2: p. 101]

For n > 30

$$T = \frac{n(p_o - \bar{x})}{\sqrt{n(1 - p_o)p_o}}, \quad \text{using } N(0,1)$$

For n < 30 the Binomial Distribution in the Statistics Module is used to directly calculate the appropriate probability for comparison with α.

4. Test Statistic for Normal σ_o^2 with μ Known [Ref. 1: p. 432; Ref. 2: p. 104]

For n < 65

$$T = T' = \frac{\sum x_i^2 + n\mu^2 - 2\mu\sum x_i}{\sigma_o^2}, \qquad \text{using } \chi^2(n)$$

For n > 65

$$T = \frac{T' - n}{\sqrt{2n}}, \qquad \text{using } N(0,1)$$

5. Test Statistic for Normal σ_o^2 with μ Unknown [Ref. 1: p. 432; Ref. 2, p. 104]

For n < 64

$$T = T' = \frac{(n-1)s_X^2}{\sigma_o^2}, \qquad \text{using } \chi^2(n-1)$$

For $n > 64$

$$T = \frac{T' - (n-1)}{\sqrt{2(n-1)}}, \qquad \text{using } N(0,1)$$

6. Test Statistic for Exponential $\mu_o = 1/\lambda_o$ [Ref. 3: p. 279]

For $n < 32$

$$T = T' = \frac{2n\bar{x}}{\mu_o}, \qquad \text{using } \chi^2(2n)$$

For $n > 32$

$$T = \frac{T' - 2n}{2\sqrt{n}}, \qquad \text{using } N(0,1)$$

7. Test Statistic for Poisson λ_o [Ref. 2: p. 248]

For $n < 30$

$$T = n\lambda_o, \qquad \text{using } \chi^2(2n\bar{x})$$

For n > 30

$$T = \frac{n\bar{x} - n\lambda_o}{\sqrt{n\lambda_o}}, \qquad \text{using } N(0,1)$$

D. THEORY FOR TWO-POPULATION HYPOTHESIS TESTS

The two-population hypothesis tests are performed in the same manner as the one-population tests. For an explanation of these tests, refer to C above. The test statistics used in Program 4 will now be listed in the same order in which they appear in the User Guide. This listing will include the assumed distribution and applicable references.

1. Test Statistic for Bernoulli $P_X = P_Y$ [Ref. 2: p. 249]

$$T = \frac{(\bar{x} - \bar{y})}{\sqrt{\left(1 - \frac{(m\bar{y} + n\bar{x})}{(m + n)}\right)\left(\frac{(m\bar{y} + n\bar{x})}{(m + n)}\right)\left(\frac{1}{n} + \frac{1}{m}\right)}}, \text{ using } N(0,1)$$

2. Test Statistic for Normal $\mu_X = \mu_Y$ for X,Y Paired [Ref. 2: p. 121]

$T = \bar{d}(\sqrt{n}/s_d)$, using $t(n-1)$ for $n < 31$, and $N(0,1)$ for $n \geq 31$

3. <u>Test Statistic for Normal $\mu_X = \mu_Y$ for X and Y Independent with $\sigma_X^2 = \sigma_Y^2$</u> [Ref. 1: pp. 434-435; Ref. 2: p. 116]

$$T = \frac{\bar{x} - \bar{y}}{s_p\sqrt{\frac{1}{n} + \frac{1}{m}}}, \text{ where } s_p = \sqrt{\frac{(n-1)s_X^2 + (m-1)s_Y^2}{n + m - 2}}$$

and using t(n+m-2) for n < 32, and N(0,1) for n $\geq$ 32

4. <u>Test Statistic for Normal $\mu_X = \mu_Y$ for X and Y Independent with σ_X^2, σ_Y^2 Known</u> [Ref. 2: p. 119]

$$T = \frac{\bar{x} - \bar{y}}{\sqrt{\frac{\sigma_X^2}{n} + \frac{\sigma_Y^2}{m}}}$$, using N(0,1)

5. <u>Test Statistic for Normal $\mu_X = \mu_Y$ for X and Y Independent with $\sigma_X^2 \neq \sigma_Y^2$</u> [Ref. 2: p. 119]

$$T = \frac{\bar{x} - \bar{y}}{\sqrt{\frac{s_X^2}{n} + \frac{s_Y^2}{m}}}$$, using N(0,1) for df $\geq$ 30, and t(df) for df < 30, where

$$df = \text{largest integer in} \left(\frac{\left(\frac{s_X^2}{n} + \frac{s_Y^2}{m}\right)^2}{\frac{\left(\frac{s_X^2}{n}\right)^2}{n} + \frac{\left(\frac{s_Y^2}{m}\right)^2}{m}} - 1.5 \right)$$

6. Test Statistic for Normal $\sigma_X^2 = \sigma_Y^2$ for X and Y Independent [Ref. 2: p. 111]

$$T = \frac{s_X^2}{s_Y^2} \quad \text{, using } F(n-1, m-1)$$

7. Test Statistic for Normal $\rho = 0$ [Ref. 1: pp. 492-493; Ref. 2: p. 200]

$$T = r\sqrt{\frac{(n-2)}{1-r^2}} \quad \text{, using } t(n-2) \text{ for } n < 28 \text{, and } N(0,1) \text{ for } n \geq 28$$

8. Test Statistic for Exponential $\lambda_X = \lambda_Y$ for X and Y Independent [Ref. 4: p. 310]

$$T = \frac{\bar{x}}{\bar{y}} \quad \text{, using } F(2n, 2m)$$

E. THEORY FOR METHODS OF APPROXIMATION

The methods used to approximate distribution values for this package of programs come from many sources, and any complete discussion of the theory involved would be beyond the scope of this paper. Therefore, while every method which

has been used will be referenced, only those methods unique to this programming effort will be discussed in theoretical detail. With this in mind, a combination listing and discussion will follow which will trace the approximation methods used in this paper. The approximations unique to this effort are the inverse cumulative distribution functions (CDF) for the Chi-Square, Student's t and F distributions as well as the Multinomial approximation. The inverse Normal CDF approximation discussed here was used in Professor Zhena's programs. All other approximations used in this paper are modifications of methods from the TI-59 Statistics Module. For a better discussion of the exact methods used in these cases, the TI-59 Applied Statistics Manual should be consulted [Ref. 7].

There are two types of inverse CDF approximations used in this paper. The first two programs use a less accurate Type I approximation, while the distribution programs use a closely related, but more accurate, Type II approximation. What follows is a discussion of the methods used for approximating the inverse Normal, Chi-Square, Student's t and F distrubitons, and the Multinomial distribution.

1. Inverse Normal CDF Approximation [Ref. 5: p. 933]

a. Type I Approximation

This approximation is used in Programs 1 and 2 for inverse Normal CDF values and as a subroutine for the Chi-Square, t and F approximations in those same programs. The Type I approximation uses the following set of equations and

constants to approximate inverse Normal CDF values, given the input probability p. Programs 1 and 2 have the limitation that p be greater than .5.

$$Z_p = t - \frac{c_0 + c_1 t + c_2 t^2}{1 + d_1 t + d_2 t^2 + d_3 t^3} \text{ , where } \quad t = \sqrt{\ln(1/(1-p)^2)} \text{ , and}$$

$c_0 = 2.515517$ $\qquad d_1 = 1.432788$

$c_1 = .802853$ $\qquad d_2 = .189269$

$c_2 = .010328$ $\qquad d_3 = .001308$

b. Type II Approximation

The Type II approximation is almost identical to the Type I approximation. The only difference is the addition of a function which removes the limitation that p be greater than .5. This function uses the symmetric quality of the Normal distribution and returns the negative of the approximation for 1-p, whenever p is less than .5.

2. Inverse Chi-Square CDF Approximation [Ref. 5: p. 941]

a. Type I Approximation

This approximation is used in Program 1 only and uses the inverse Normal CDF approximation described above. The inverse Chi-Square CDF approximation uses the following set of equations and calculates both $\chi^2_{(1-p)}(v)$ and $\chi^2_{(p)}(v)$ given the input probability p. The reference listed above limits degrees of freedom, v, for this approximation to values above 30; however, as can be seen in Appendix B values well below v = 30 produce acceptable approximations.

$$\chi^2_p(v) = v(1 - a + z_p\ a)^3\ ,\ \text{where } a = \frac{2}{9v}$$

b. Type II Approximation

This approximation is used only in Program 7 and incorporates the Type I inverse Chi-Square CDF approximation with an Accuracy Enhancing Technique (AET) which requires the highly accurate forward Chi-Square CDF approximation contained in that same program. This AET involves taking the output of the Type I approximation and using it in the forward CDF approximation to obtain an estimate, $\hat{p}$, of the actual probability achieved by the Type I approximation. This estimate is then used to correct the inverse approximation input, p, for any difference between desired and actual probability. The corrected inverse input, p', is computed using the following formula:

$$p' = p + (p - \hat{p})\ .$$

By using p' as the new input for the inverse CDF approximation, a more accurate approximation is achieved (see Appendix B). This AET is not used for $v > 30$ since the Type I approximation is then quite accurate.

3. Inverse Student's t CDF Approximation

a. Type I Approximation

This approximation is used in Programs 1, 2, 8 and 9 and requires the inverse Normal CDF approximation already described. The following equation represents one of

several approximations to the inverse t developed by Professor Donald P. Gaver, Naval Postgraduate School. This approximation is limited to values of $v \geq 2$ [Ref. 8].

$$t_p(v) = Z_p\left(1 + Z_p^{\,2}\left(\frac{-1 + \sqrt{1 + \frac{10}{3(v - 1.57)}}}{5}\right)\right), \quad v \geq 2$$

b. Type II Approximation

This approximation is used only in Program 8 and, like the Type II Chi-Square approximation, uses an AET to increase the accuracy of the Type I approximation. The procedures for this AET are exactly the same as in the Chi-Square approximation. Additionally, the restriction on v has been removed by using the following relationship to generate inverse approximations when $v = 1$.

$$t_p(1) = \frac{1}{\tan(1-p)}$$, where for $p < .5$, $2p$ is used in place of p

4. Inverse F CDF Approximation [Ref. 5: p. 947]

a. Type I Approximation

This approximation is used in Programs 1 and 2 and uses the inverse Normal approximation discussed earlier. The following set of equations is used to generate the approximation:

$$F_p(v_1, v_2) = e^{2w}, \text{ where } w = \frac{Z_p\sqrt{(h + k)}}{h}, \; k = \frac{Z_p{}^2 - 3}{6},$$

$$h = \frac{1}{2(1/(v_1 - 1) + 1/(v_2 - 1))}, \text{ and } v_1 \neq 1, \; v_2 \neq 1$$

b. Type II Approximation

This approximation uses the AET discussed earlier along with two more techniques to provide inverse approximations for all values of v_1 and v_2. For the case where v_1 or $v_2 = 1$, the Type I inverse t approximation discussed earlier is used in the following relationships to generate the required inverse F CDF approximations:

$$F_p(1,v) = (t_{(1+p)/2}(v))^2 \quad \text{, or equivalently}$$

$$F_p(v,1) = \left(\frac{1}{t_{(1+p)/2}(v)}\right)^2 .$$

For the case where $v_1 = v_2 = 1$, the following relationship is used:

$$F_p(1,1) = \frac{1}{\tan(1-p)} .$$

5. Multinomial Approximation

The method used to generate multinomial density values is not truly unique; however, it uses the following equation in a way that minimizes rounding errors:

$$f_N(n_1, n_2, \ldots, n_k) = \frac{N!}{(n_1!)(n_2!)\ldots(n_k!)}(p_1^{n_1})(p_2^{n_2})\ldots(p_k^{n_k}).$$

Computations are accomplished in the following order to avoid, as much as possible, multiplying extremely small values by extremely large values:

$$\left(\frac{N(p_1^{n_1})}{n_1!}\right)\left(\frac{(N-1)(p_2^{n_2})}{n_2!}\right)\ldots\left(\frac{(N-k)(p_k^{n_k})}{n_k!}\right)(N-k-1)!\ .$$

IV. TI-59

The choice of the TI-59 as the calculator for this programming effort was based on two factors. Professor Zehna's original programs were written for the TI-59; and each student in the Operations Research (OR) curriculum is issued a TI-59 for use in basic probability and statistics courses. In general, the use of hand-held programmable calculators has been shown [Ref. 6: p. 1] to increase student learning and capability. Further, it is intended that the programs described in this paper will be used by OR students in their coursework.

Using the TI-59 offered some disadvantages and some advantages in developing the programming package presented here. The disadvantages of limited storage, slow computation time and awkward data entry sequence are discussed elsewhere in this paper. There are two advantages of the TI-59, however, that deserve noting here. The programming steps and procedures used in the TI-59 are easily learned and logical. This ease of programming makes complex computational methods easy to program. Another advantage of the TI-59 is its compatibility with the PC-100C printer. Using the printer/calculator combination greatly simplifies writing, editing, and error diagnosis. These advantages of the TI-59 make programming relatively easy and also allow the capabilities of the TI-59 to be used more fully.

V. ALTERNATE SOLUTIONS

The problems presented in this paper could have been solved in any number of equally valid ways. This section will briefly discuss the specific alternatives which could increase the capability of the solutions employed here. This discussion will first focus on alternative hardware which could be used, and then on program changes which might be made.

A. HARDWARE ALTERNATIVES

As discussed earlier, the use of the TI-59 calculator is appropriate for this programming package; however, the methods and techniques used in this paper are equally suited to other programmable calculators or computers. Indeed, the use of any other calculator or computer with more storage capability than the TI-59 might be a better vehicle for the package of programs presented here. These programs require a total of 14 magnetic cards (22 separate sides) using the TI-59. Current console model computers could easily store all of these programs at the same time.

The TI-59 has the ability to use program modules, and the nine programs from this package could easily be combined to form the basis of a new module. By careful elimination of redundant functions, such a module could also accommodate an ANOVA and/or regression package. A module of this type might find widespread acceptance, especially in the classroom.

B. PROGRAMMING ALTERNATIVES

The choice of distribution approximating methods used here and the general layout of the entire package might both be improved with some additional effort. The methods of approximation used here were chosen rather arbitrarily. It is possible that more appropriate methods of approximation exist. More appropriate methods might include methods with fewer program steps and equal accuracy, as well as methods which take less computation time with equal accuracy.

The current layout of the nine programs in this package might be improved by reducing the number of programs. The present program size precludes this; however, by eliminating some program functions, it might be possible to organize all of the inverse CDF approximations in one program. Shorter approximating methods might make possible a similar program, but with both inverse CDF and regular CDF approximations.

The extensive user guides with their sample problems are useful for students, but could prove awkward for a more experienced user. An obvious alternative would be a shortened user guide directed at those more familiar with the programs.

VI. CONCLUSION

Two problems were presented for solution in this paper. One problem involved expanding and modifying an existing set of TI-59 programs into a user-friendly package. A second problem involved developing a set of distribution approximating programs. The solution to the first problem incorporated increased capability, standardized data entry, and detailed user guides into a package of nine programs. The first priority in this solution was providing a format compatible with a student's needs while maintaining the capability required by a more experienced user. The TI-59 calculator proved to be a very useful tool in this solution, and demonstrated the generally unused capability of the current generation of hand-held programmable calculators.

The approximation programs presented as a solution to the second problem mentioned above provide accurate and comprehensive approximations. These programs practically eliminate the need for tables of values and solve the interpolation problem present in all such tables.

Together these two solutions represent a package with considerable capability in computing confidence intervals, performing hypothesis tests, and generating approximate distribution values. A comprehensive set of user guides makes this same capability available even to inexperienced users. The methods used in preparing this TI-59 programming

package are directly applicable to other calculators or computers.

APPENDIX A

PROGRAM 1 USER GUIDE - One-Population Confidence Intervals

INTRODUCTION: The purpose of this program is to compute 100γ% confidence intervals (l,u) or bounds [l and u] for the following one-population situations:

NORMAL	μ with σ^2 known
NORMAL	μ with σ^2 unknown
BERNOULLI	p
NORMAL	σ^2 with μ known
NORMAL	σ^2 with μ unknown
EXPONENTIAL	λ or μ .

The routines in this program require percentiles from either the Normal, Chi-Square, Student's t or F distributions. Each routine will automatically generate an approximate percentile; however, when additional accuracy is desired or small sample sizes are involved the use of percentile values from either standard tables or the distribution approximating programs is recommended. In step two of each routine the user can choose to accept the approximate percentile, by storing the appropriate percentage in storage register 09 (R_{09}), or he can store the percentile value in R_{11}. Some routines also require percentile values in R_{13}.

GENERAL PROCEDURES:

1. Use any library module, and after reading all three card sides, press $\boxed{D}$ to repartition (639.39).

2. For data entry press $\boxed{D}$ followed by data point x_i, $\boxed{R/S}$, x_i, $\boxed{R/S}$, etc. for each x_i (i=1,2,...,n) until all points have been

entered. Mistakes in data entry should be corrected immediately by reentering the unwanted point and pressing [INV] [2nd] [Σ+], then enter the correct data point and press [R/S] [R/S]. Alternate data entry using summary statistics is detailed in applicable routines.

3. For one-sided confidence bounds rather than intervals replace $(1+\gamma)/2$ with γ and $(1-\gamma)/2$ with $1-\gamma$ everywhere they appear (e.g. $z_{(1+\gamma)/2}$ becomes z_γ) and proceed as usual, ignoring l or u as appropriate.

4. When solving consecutive problems, care should be taken to clear all previously used registers. Pressing [D] will clear all registers.

<u>PROGRAM 1 SPECIFIC PROCEDURES</u>:

<u>C.I. For NORMAL μ with σ^2 known</u>

1. Enter data using [D] and store σ in R_{07} (Alternate entry: store n in R_{03}, $\bar{x}$ in R_{08} and σ in R_{07})
2. Store <u>either</u> $(1+\gamma)/2$ in R_{09} <u>OR</u> $z_{(1+\gamma)/2}$ in R_{11}
3. Press [A] l is displayed, then press [x⋛t] u is displayed

<u>C.I. For NORMAL μ with σ^2 unknown</u>

1. Enter data using [D] (Alternate entry: store n in R_{03}, s in R_{07} and $\bar{x}$ in R_{08})
2. Store <u>either</u> $(1+\gamma)/2$ in R_{09} <u>OR</u> $t_{(1+\gamma)/2}(n-1)$ in R_{11}
3. Press [C] l is displayed, then press [x⋛t] u is displayed

C.I. For BERNOULLI p

1. Store $n\bar{x}$ in R_{01} and n in R_{03}

2. Store either $(1+\gamma)/2$ in R_{09} OR $F_{(1+\gamma)/2}(2n\bar{x}+2, 2n-2n\bar{x})$ in R_{11}

   AND

   $F_{(1+\gamma)/2}(2n-2n\bar{x}+2, 2n\bar{x})$ in R_{13}

3. Press $\boxed{B}$ 1 is displayed, then

   press $\boxed{x \gtrless t}$ u is displayed

C.I. For NORMAL σ^2 with μ known

1. Enter data using $\boxed{D}$ and store μ in R_{08} (Alternate entry: store $\sum x_i^2$ in R_{02}, n in R_{03} and μ in R_{08})

2. Store either $(1+\gamma)/2$ in R_{09} OR $\chi^2_{(1-\gamma)/2}(n)$ in R_{11}

   AND

   $\chi^2_{(1+\gamma)/2}(n)$ in R_{13}

3. Press $\boxed{C'}$ 1 is displayed, then

   press $\boxed{x \gtrless t}$ u is displayed

C.I. For NORMAL ^{2} with unknown

1. Enter data using $\boxed{D}$ (Alternate entry: store n in R_{03} and $(n-1)s^2$ in R_{12})

2. Store either $(1+\gamma)/2$ in R_{09} OR $\chi^2_{(1-\gamma)/2}(n-1)$ in R_{11}

   AND

   $\chi^2_{(1+\gamma)/2}(n-1)$ in R_{13}

3. Press $\boxed{D'}$ 1 is displayed, then

   press $\boxed{x \gtrless t}$ u is displayed

C.I. For EXPONENTIAL λ or μ^*

1. Enter data using $\boxed{D}$ (Alternate entry: store n in R_{03} and $\bar{x}$ in R_{08})
2. Store either $(1+\gamma)/2$ in R_{09} OR $\chi^2_{(1-\gamma)/2}(2n)$ in R_{11}

   AND

   $\chi^2_{(1+\gamma)/2}(2n)$ in R_{13}
3. Press $\boxed{E}$ l is displayed, then

   press $\boxed{x \gtrless t}$ u is displayed

* 4. To compute a confidence interval or bound for $\mu = 1/\lambda$ press $\boxed{E'}$ rather than $\boxed{E}$ above.

PROGRAM 1 ADDITIONAL CAPABILITIES:

Inverse Normal CDF Approximation

1. Store p in R_{09} $(p > .5)$
2. Press $\boxed{B'}$ z_p is displayed, and

   $z_{(1-p)}$ is available in R_{13}

Inverse Chi-Square CDF Approximation

1. Store p in R_{09} $(p > .5)$, and store v in R_{14} $(v \neq 1)$
2. Press $\boxed{SBR}$ $\boxed{X^2}$ $\chi^2_p(v)$ is displayed, and

   $\chi^2_{(1-p)}(v)$ is available in R_{11}

Inverse F CDF Approximation

1. Store p in R_{09} $(p > .5)$, v_1 in R_{20} and v_2 in R_{21} $(v_1 \neq 1, v_2 \neq 1)$
2. Press $\boxed{SBR}$ $\boxed{RCL}$ $F_p(v_1, v_2)$ is displayed

Inverse Student's t CDF Approximation

1. Store p in R_{09} $(p > .5)$ and v in R_{19} $(v \neq 1)$
2. Press $\boxed{SBR}$ $\boxed{STO}$ $t_p(v)$ is displayed

PROGRAM 1 LABELS USED:

A	A'	SBR	RCL
B	B'	GTO	STO
C	C'	$x \gtrless t$	
D	D'	X^2	
E	E'	=	

PROGRAM 1 STORAGE REGISTER CONTENTS:

00	clear	15	used
01	$\sum x$	16	clear
02	$\sum x_i^2$	17	clear
03	n	18	clear
04	used	19	v
05	clear	20	v_1
06	clear	21	v_2
07	s or σ	22	clear
08	$\bar{x}$ or μ	23	clear
09	$(1+\gamma)/2$ or p	24	used
10	used	25	clear
11	CDF value	26	clear
12	$(n-1)s^2$	27	used
13	CDF value	28	used
14	v	29-49	clear

PROGRAM 1 SAMPLE PROBLEMS:

1. Suppose $\bar{x} = 69.7$, $n = 8$, $\sigma^2 = 3.5$. Find a 90% C.I. for estimating the mean.

SOLUTION:

(1) Store n=8 in R_{03}, $\bar{x} = 69.7$ in R_{08} and $\sigma = \sqrt{3.5}$ in R_{07}

(2) Store $(1+\gamma)/2 = .95$ in R_{09} OR $z_{.95} = 1.645$ in R_{11}

(3) Press $\boxed{A}$ then $\boxed{x \gtrless t}$ to display

l = 68.61179492	OR	l = 68.61193477
u = 70.78820508		u = 70.78806523

2. Given the following observations from a population with a known variance of 15, find a lower 99% confidence bound on the mean.

165 178 160 199 167 145 157 182 192 165

SOLUTION:

(1) Enter data using $\boxed{D}$ sequence and store $\sigma = \sqrt{15}$ in R_{07}

(2) Store $\gamma = .99$ in R_{09} OR $z_{.99} = 2.326$ in R_{11}

(3) Press $\boxed{A}$ then $\boxed{x \gtrless t}$ to display

l = 168.1502816	OR	l = 168.1512434
ignore u		ignore u

3. Find a 90% C.I. for the mean of the following test scores.

35 34 46 20 38 39 32 49 41 25 18 43 51 38 42 29 59 53 27 33

SOLUTION:

(1) Enter data using $\boxed{D}$ sequence

(2) Store $(1+\gamma)/2 = .95$ in R_{09} OR $t_{.95}(19) = 1.729$ in R_{11}

(3) Press $\boxed{C}$ then $\boxed{x \gtrless t}$ to display

l = 33.39962583	OR	l = 33.39390952
u = 41.80037417		u = 41.80609048

4. Find a 95% upper confidence bound for μ given the following information: $n = 55$, $s = 15$ and $\bar{x} = 85$.

SOLUTION:

(1) Store $n = 55$ in R_{03}, $s = 15$ in R_{07} and $\bar{x} = 85$ in R_{08}

(2) Store $\gamma = .95$ in R_{09} OR $t_{.95}(54) = 1.673$ in R_{11}

(3) Press $\boxed{C}$ then $\boxed{x \gtrless t}$ to display

ignore l		ignore l
u = 88.38398464	OR	u = 88.38380911

5. Of 1000 people treated with a certain drug 200 showed a reaction. Find a 90% C.I. for the proportion of the sample population that will show a reaction.

SOLUTION:

(1) Press $\boxed{D}$ then store $n\bar{x} = 200$ in R_{01} and $n = 1000$ in R_{03}

(2) Store $(1+\gamma)/2 = .95$ in R_{09} OR $F_{.95}(402,1600) = 1.13$ in R_{11}

AND

$F_{.95}(1602,400) = 1.14$ in R_{13}

(3) Press $\boxed{B}$ then $\boxed{x \gtrless t}$ to display

l = .1793622306		l = .1796719191
u = .2219574577	OR	u = .2211307235

6. Find a 95% upper confidence bound for the proportion of the sample population if nine of 24 treated were affected.

SOLUTION:

(1) Press $\boxed{D}$ then store $n\bar{x} = 9$ in R_{01} and $n = 24$ in R_{03}

(2) Store $\gamma = .95$ in R_{09} OR $F_{.95}(20,30) = 1.93$ in R_{11}

AND

$F_{.95}(32,18) = 2.13$ in R_{13}

(3) Press $\boxed{B}$ then $\boxed{x \gtrless t}$ to display

ignore 1 OR ignore 1

u = .5629409878 OR u = .5626822157

7. Find a 95% C.I. for σ^2 and for σ given the following observations from a sample population with $\mu = 65.0$.

100 15 73 46 65 98 79 38 68 85

SOLUTION:

(1) Enter data using $\boxed{D}$ and store $\mu = 65$ in R_{08}

(2) Store $(1+\gamma)/2 = .975$ in R_{09} OR $\chi^2_{.025}(10) = 3.25$ in R_{11}

AND

$\chi^2_{.975}(10) = 20.48$ in R_{13}

(3) Press $\boxed{C'}$ then $\boxed{x \gtrless t}$ to display (for σ^2)

l = 428.7608301 OR l = 428.8574219

u = 2726.124604 OR u = 2702.461538

Taking square roots the following limits for σ are displayed

l = 20.70654076 OR l = 20.70887302

u = 52.21230319 OR u = 51.985205

8. Suppose $n = 15$, $\sum x_i^2 = 88476$ and $\mu = 30.5$. Find a 97.5% upper confidence bound on the standard deviation.

SOLUTION:

(1) Press $\boxed{D}$ then store $\sum x_i^2 = 88476$ in R_{02}, $n = 15$ in R_{03} and $\mu = 30.5$ in R_{08}

(2) Store $\gamma = .975$ in R_{09} OR $\chi^2_{.025}(15) = 6.26$ in R_{11}

AND

$\chi^2_{.975}(15) = 27.49$ in R_{13}

(3) Press $\boxed{C'}$ then $\boxed{x \gtrless t}$ and take square root to display

ignore l

u = 109.2668647

OR

ignore l

u = 109.1078035

9. Find a 95% C.I. for σ given the following observations.

100 15 73 46 65 98 79 38 68 85

SOLUTION:

(1) Enter data using $\boxed{D}$

(2) Store $(1+\gamma)/2 = .975$ in R_{09} OR $\chi^2_{.025}(9) = 2.70$ in R_{11}

AND

$\chi^2_{.975}(9) = 19.02$ in R_{13}

(3) Press $\boxed{D'}$ then $\boxed{x \gtrless t}$, and take square roots to display

l = 18.54742

u = 49.47192697

OR

l = 18.54896609

u = 49.23150151

10. Suppose $n = 45$ and $s^2 = 36$ find a 90% lower confidence bound for σ^2.

SOLUTION:

(1) Press $\boxed{D}$ then store $n = 45$ in R_{03} and $(n-1)s^2 = 1584$ in R_{12}

(2) Store $\gamma = .90$ in R_{09} OR $\chi^2_{.10}(44) = 32.5$ in R_{11}

AND

$\chi^2_{.90}(44) = 56.4$ in R_{13}

(3) Press $\boxed{D'}$ to display

$l = 28.10395538$	OR	$l = 28.08510638$
ignore u		ignore u

11. Given the time to failure of an electron tube is an exponential random variable, and the sum of 25 times to failure is 25242. Find a 95% C.I. for λ.

SOLUTION:

(1) Press $\boxed{D}$ then store $n = 25$ in R_{03} and $\bar{x} = 25242/25$ in R_{08}

(2) Store $(1+\gamma)/2 = .975$ in R_{09} OR $\chi^2_{.025}(50) = 31.92$ in R_{11}

AND

$\chi^2_{.975}(50) = 70.92$ in R_{13}

(3) Press $\boxed{E}$ then $\boxed{x \gtrless t}$ to display

$l = .0006407042$	OR	$l = .0006322795$
$u = .001414878$		$u = .0014048015$

12. Six expensive pieces of equipment had the following times to failure. Find a 95% C.I. for the mean time to failure.

233.6 3119.0 258.3 1402.7 612.9 2211.2

SOLUTION:

(1) Enter data using $\boxed{\text{D}}$

(2) Store $(1+\gamma)/2 = .975$ in R_{09} OR $\chi^2_{.025}(12) = 4.40$ in R_{11}

AND

$\chi^2_{.975}(12) = 23.34$ in R_{13}

(3) Press $\boxed{\text{E}'}$ then $\boxed{x \rightleftarrows t}$ to display

l = 671.6219738	OR	l = 671.6109683
u = 3578.128804		u = 3562.590909

PROGRAM 2 USER GUIDE - Two-Population Confidence intervals:

INTRODUCTION: The purpose of this program is to compute $100\gamma\%$ confidence intervals (l,u) or bounds [l and u] for the following two-population situations.

BERNOULLI	$p_X - p_Y$	for large sample sizes
NORMAL	$\mu_X - \mu_Y$	for X and Y paired with σ^2 unknown
NORMAL	$\mu_X - \mu_Y$	for X and Y independent with $\sigma_X^2 = \sigma_Y^2 = \sigma^2$
NORMAL	$\mu_X - \mu_Y$	for X and Y indep with σ_X^2 and σ_Y^2 known
NORMAL	σ_X^2/σ_Y^2	for X and Y independent
EXPONENTIAL	$\lambda_X/\lambda_Y = \mu_Y/\mu_X$	for X and Y independent

The routines in this program require percentiles from either the Normal, Student's t or F distributions. Each routine will automatically generate an approximate percentile; however, when additional accuracy is desired or small sample sizes are involved the use of percentile values from either standard tables or the distribution approximating programs is recommended. In step two of each routine the user can choose to accept the approximate percentile, by storing the appropriate percentage in R_{09}, or he can store the the percentile value in R_{11}. Some routines also require percentile values in R_{13}.

GENERAL PROCEDURES:

1. Use any library module, and after reading all three card sides, press $\boxed{D}$ to repartition (719.29).

2. Data entry for independent data (DEI Sequence), press $\boxed{D}$ followed by data point x_i, $\boxed{R/S}$, x_{i+1}, $\boxed{R/S}$, etc. for each x_i ($i=1,2,\ldots,n$). When all of the x_i's have been entered press $\boxed{D'}$ followed by data point y_i, $\boxed{R/S}$, y_{i+1}, $\boxed{R/S}$, etc. for each y_i ($i=1,2,\ldots,m$).

When all of the y_i's have been entered press $\boxed{\text{SBR}}$ $\boxed{\text{GTO}}$. Mistakes in data entry should be corrected immediately by reentering the unwanted data point and pressing $\boxed{\text{INV}}$ $\boxed{\text{2nd}}$ $\boxed{\Sigma+}$, then enter the correct data point and press $\boxed{\text{R/S}}$ $\boxed{\text{R/S}}$. Alternate data entry using summary statistics is detailed in applicable routines.

3. Data entry for paired data (DEP Sequence), press $\boxed{\text{D}}$ followed by x_i, $\boxed{x\gtrless t}$, y_i, $\boxed{\text{R/S}}$, x_{i+1}, $\boxed{x\gtrless t}$, y_{i+1}, $\boxed{\text{R/S}}$, etc. for each data pair x_i, y_i $(i=1,2,\ldots,n)$, then press $\boxed{\text{SBR}}$ $\boxed{\text{RST}}$. Mistakes and alternate entry are as above.

4. For confidence bounds rather than intervals, replace $(1+\gamma)/2$ with γ everywhere it appears (e.g. $t_{(1+\gamma)/2}(v)$ becomes $t_\gamma(v)$) and proceed as usual ignoring either l or u as appropriate.

5. When solving consecutive problems, care should be taken to clear all previously used storage registers. Pressing $\boxed{\text{D}}$ will clear all registers.

<u>PROGRAM 2 SPECIFIC PROCEDURES</u>:

<u>C.I. For BERNOULLI</u> $p_X - p_Y$ <u>for large sample sizes</u>*

1. Press $\boxed{\text{D}}$ then store $n\bar{x}$ in R_{01}, $m\bar{y}$ in R_{02} n in R_{03}, m in R_{04}
2. Store either $(1+\gamma)/2$ in R_{09} <u>OR</u> $z_{(1+\gamma)/2}$ in R_{11}
3. Press $\boxed{\text{B}}$ l is displayed, then

   press $\boxed{x\gtrless t}$ u is displayed

* Large here means np_X, mp_Y, $n(1-p_X)$, $m(1-p_Y)$ all greater than five.

C.I. For NORMAL $\mu_X - \mu_Y$ for paired X and Y (n pairs)

1. Enter data using DEP Sequence, degrees of freedom, $v = n-1$, will be displayed. (Alternate entry: store $\bar{x}-\bar{y}$ in R_{10}, $s_d/\sqrt{n}$ in R_{12} and n-1 in R_{19})
2. Store either $(1+\gamma)/2$ in R_{09} OR $t_{(1+\gamma)/2}(n-1)$ in R_{11}
3. Press $\boxed{C}$ 1 is displayed, then press $\boxed{x \gtrless t}$ u is displayed
4. When differences, $x_i - y_i$, are given use Program 1.

C.I. For NORMAL $\mu_X - \mu_Y$ with $\sigma_X^2 = \sigma_Y^2 = \sigma^2$ unknown

1. Enter data using DEI Sequence, degrees of freedom, $v = n+m-2$ is displayed. (Alternate entry #1: Store n in R_{15}, m in R_{03}, $\bar{x}-\bar{y}$ in R_{10}, $\sum(x_i-\bar{x})^2$ in R_{16}, $\sum(y_i-\bar{y})^2$ in R_{26} and (n+m-2) in R_{19}) (Alternate entry #2: Store n in R_{03}, $\sum x_i$ in R_{01}, $\sum x_i^2$ in R_{02}, then press $\boxed{D'}$, store m in R_{03}, $\sum y_i$ in R_{01} and $\sum y_i^2$ in R_{02}, then press $\boxed{SBR}$ $\boxed{GTO}$, v is displayed)
2. Store either $(1+\gamma)/2$ in R_{09} OR $t_{(1+\gamma)/2}(n+m-2)$ in R_{11}
3. Press $\boxed{C}$ 1 is displayed, then press $\boxed{x \gtrless t}$ u is displayed

C.I. For NORMAL $\mu_X - \mu_Y$ with σ_X^2 and σ_Y^2 known

1. Enter data using DEI Sequence, then store σ_X^2/n in R_{17} and σ_Y^2/m in R_{07} (Alternate entry: store $\bar{x}-\bar{y}$ in R_{10} and $\sqrt{(\sigma_X^2/n) + (\sigma_Y^2/m)}$ in R_{12})
2. Store either $(1+\gamma)/2$ in R_{09} OR $z_{(1+\gamma)/2}$ in R_{11}
3. Press $\boxed{A}$ 1 is displayed, then press $\boxed{x \gtrless t}$ u is displayed

C.I. For NORMAL σ_X^2/σ_Y^2

1. Enter data using DEI Sequence (Alternate entry: store n in R_{15}, s_X^2 in R_{17}, m in R_{03} and s_Y^2 in R_{07})
2. Store either $(1+\gamma)/2$ in R_{09} OR $F_{(1+\gamma)/2}(n-1,m-1)$ in R_{11} AND $F_{(1+\gamma)/2}(m-1,n-1)$ in R_{13}
3. Press $\boxed{E}$ 1 is displayed, then press $\boxed{x \gtrless t}$ u is displayed

C.I. For EXPONENTIAL $\lambda_X/\lambda_Y = \mu_Y/\mu_X$

1. Enter data using DEI Sequence (Alternate entry: store n in R_{15}, $\bar{x}$ in R_{18}, m in R_{03} and $\bar{y}$ in R_{08})
2. Store either $(1+\gamma)/2$ in R_{09} OR $F_{(1+\gamma)/2}(2m,2n)$ in R_{11} AND $F_{(1+\gamma)/2}(2n,2m)$ in R_{13}
3. Press $\boxed{E'}$ 1 is displayed, then press $\boxed{x \gtrless t}$ u is displayed

PROGRAM 2 ADDITIONAL CAPABILITIES:

Inverse Normal CDF Approximation

1. Store p in R_{09} ($p > .5$)
2. Press $\boxed{B'}$ to display z_p

Inverse Student's t CDF Approximation

1. Store p in R_{09} ($p > .5$) and v in R_{19} ($v \neq 1$)
2. Press $\boxed{SBR}$ $\boxed{RCL}$ to display $t_p(v)$

Inverse F CDF Approximation

1. Store p in R_{09} ($p > .5$), v_1 in R_{20} and v_2 in R_{21} ($v_1 \neq 1, v_2 \neq 1$)
2. Press $\boxed{SBR}$ $\boxed{STO}$ to display $F_p(v_1,v_2)$

PROGRAM 2 LABELS USED

A	A'	GTO	EE
B	B'	RST	
C	=	SBR	
D	D'	STO	
E	E'	RCL	

PROGRAM 2 STORAGE REGISTER CONTENTS:

00	clear	15	n
01	$n\bar{x}$ or $\sum y_i$	16	used
02	$m\bar{y}$ or $\sum y_i^2$	17	s_X^2 or σ_X^2/n
03	n or m	18	$\bar{x}$
04	m or $\sum x_i$	19	v or (n-1)
05	$\sum x_i^2$	20	v_1
06	$\sum x_i y_i$	21	v_2
07	s_Y^2 or σ_Y^2/m	22	clear
08	$\bar{y}$	23	used
09	p or $(1+\gamma)/2$	24	used
10	$\bar{x}-\bar{y}$	25	clear
11	CDF value	26	clear
12	$s_d/\sqrt{n}$	27	used
13	CDF value	28	used
14	used	29	used

PROGRAM 2 SAMPLE PROBLEMS:

1. In a survey of 400 people from one city 188 preferred Brand A soap to all others; and in a sample of 500 people from another city 210 preferred the same product. Find a 95% confidence interval for $p_X - p_Y$.

SOLUTION:

(1) Press $\boxed{D}$ then store $n\bar{x} = 188$ in R_{01}, $m\bar{y} = 210$ in R_{02}, $n = 400$ in R_{03} and $m = 500$ in R_{04}

(2) Store $(1+\gamma)/2 = .975$ in R_{09} OR $z_{.975} = 1.960$ in R_{11}

(3) Press $\boxed{B}$ then $\boxed{x \gtrless t}$ to display

l = -.0153123448	OR	l = -.0152991877
u = .1153123448		u = .1152991877

2. In a survey of dieting effects, ten women were selected, weighed and placed on a diet for two weeks. At the end of that time they were reweighed. The results are listed below. Find a 99% confidence interval for the difference in means. Also find a 95% upper confidence bound for the difference in means.

Before	119	122	136	130	129	136	134	133	119	115
After	114	119	134	126	119	137	124	127	119	107

SOLUTION Part a.

(1) Enter data using DEP Sequence, 9 is displayed

(2) Store $(1+\gamma)/2 = .995$ in R_{09} OR $t_{.995}(9) = 3.250$ in R_{11}

(3) Press $\boxed{C}$ then $\boxed{x \gtrless t}$ to display

l = .7054594846	OR	l = .7328694249
u = 8.694540515		u = 8.667130575

SOLUTION Part b.

(1) Enter data using DEP Sequence, 9 is displayed

(2) Store $\gamma = .95$ in R_{09} OR $t_{.95}(9) = 1.833$ in R_{11}

(3) Press $\boxed{C}$ then $\boxed{x \gtrless t}$ to display

ignore l	OR	ignore l
u = 6.92957002		u = 6.9374616'4'4

3. Suppose $\bar{x} = 10$, $\bar{y} = 5$, $n = 25$, and $s_d = 10$; find a 90% C.I. for $\mu_X - \mu_Y$.

SOLUTION:

(1) Press $\boxed{D}$ then s ore $\bar{x}-\bar{y} = 5$ in R_{10}, $s_d/\sqrt{n} = 2$ in R_{12} and $(n-1) = 24$ in R_{19}

(2) Store $(1+\gamma)/2$ in R_{09} OR $t_{.95}(24) = 1.711$ in R_{11}

(3) Press $\boxed{C}$ then $\boxed{x \gtrless t}$ to display

l = 1.581803572	OR	l = 1.578
u = 8.418196428		u = 8.422

4. Two small classes used different, but equivalent methods on a common exam. Their scores are listed below. Find a 90% confidence interval and a 90% lower bound for the difference in means.

X: 82 87 91 54 97 76 64 98 92 57 80 53 64

Y: 91 62 94 92 87 79 86 75 90 73 83 93 65 89 68 52

SOLUTION: Part a.

(1) Enter data using DEI Sequence, v = 27 is displayed

(2) Store $(1+\gamma)/2 = .95$ in R_{09} OR $t_{.95}(27) = 1.703$ in R_{11}

(3) Press $\boxed{C}$ then $\boxed{x \gtrless t}$ to display

l = -12.62699316	OR	l = -12.63357801
u = 5.828916241		u = 5.835501092

SOLUTION Part b.

(1) Enter data using DEI Sequence, v = 27 is displayed

(2) Store $\gamma = .90$ in R_{09} OR $t_{.90}(27) = 1.314$ in R_{11}

(3) Press $\boxed{C}$ to display

l = -10.49428744	OR	l = -10.52422048
ignore u		ignore u

5. Suppose n = 16, m = 15, $\bar{x} = 14.3$, $\bar{y} = 12.5$, $\sum(x_i-\bar{x})^2 = 67.2$ and $\sum(y_i-\bar{y})^2 = 103.7$. Find a 99% upper confidence bound for the difference in means.

SOLUTION:

(1) Press $\boxed{D}$ then store n = 16 in R_{15}, m = 15 in R_{03}, $\bar{x}-\bar{y} = 1.8$ in R_{10}, $\sum(x_i-\bar{x})^2 = 67.2$ in R_{16}, $\sum(y_i-\bar{y})^2 = 103.7$ in R_{26} and (n+m-2) = 29 in R_{19}

(2) Store $\gamma = .99$ in R_{09} OR $t_{.99}(29) = 2.462$ in R_{11}

(3) Press $\boxed{C}$ then $\boxed{x \gtrless t}$ to display

ignore l	OR	ignore l
u = 3.959764742		u = 3.948005095

6. Suppose n = 32, m = 10, $\bar{x} = 13$, $\bar{y} = 15$, $\sigma_X^2 = 16$ and $\sigma_Y^2 = 25$; find a 95% confidence interval for $\mu_X-\mu_Y$.

SOLUTION:

(1) Press $\boxed{D}$ then store $\bar{x}-\bar{y} = 2$ in R_{10} and $\sqrt{(\sigma_X^2/n) + (\sigma_Y^2/m)} = \sqrt{3}$ in R_{12}

(2) Store $(1+\gamma)/2 = .975$ in R_{09} OR $z_{.975} = 1.960$ in R_{11}

(3) Press $\boxed{A}$ then $\boxed{x \gtrless t}$ to display

l = -1.395503599	OR	l = -1.394819583
u = 5.395503599		u = 5.394819583

7. Given the following sets of data with known variance, estimate the difference in means with a 90% confidence interval.

$\sigma_X^2 = 3.7$ and $\sigma_Y^2 = 2.5$

X: 3.6 4.7 2.4 1.7 6.2 7.2 3.6

Y: 5.4 7.6 4.3 6.5 8.7 4.5 6.1 8.6

SOLUTION:

(1) Enter data using DEI Sequence and store $\sigma_X^2/n = 3.7/7$ in R_{17} and $\sigma_Y^2/m = 2.5/8$ in R_{07}

(2) Store $(1+\gamma)/2 = .95$ in R_{09} OR $z_{.95} = 1.645$ in R_{11}

(3) Press $\boxed{A}$ then $\boxed{x \gtrless t}$ to display

l = -3.771322531	OR	l = -3.77112862
u = -.7536774686		u = -.7538713802

8. Find a 99% confidence interval for σ_X^2/σ_Y^2 using the following data.

X: 82 87 91 54 97 76 64 98 92 57 80 53 64

Y: 91 62 94 92 87 79 86 75 90 73 83 93 65 89 68 52

SOLUTION:

(1) Enter data using DEI Sequence

(2) Store $(1+\gamma)/2 = .995$ in R_{09} OR $F_{.995}(12,15)=4.25$ in R_{11}

AND

$F_{.995}(15,12) = 4.72$ in R_{13}

(3) Press $\boxed{E}$ then $\boxed{x \gtrless t}$ to display

l = .3864689829	OR	l = .3875258108
u = 7.818933411		u = 7.773767765

9. Find a 95% confidence interval for σ_X^2/σ_Y^2 given n = 8, m = 11, $s_X^2 = 4$ and $s_Y^2 = 3.6$.

SOLUTION:

(1) Press $\boxed{D}$ then store n = 8 in R_{15}, m = 11 in R_{03}, $s_X^2 = 4$ in R_{17} and $s_Y^2 = 3.6$ in R_{07}

(2) Store $(1+\gamma)/2 = .975$ in R_{09} OR $F_{.975}(7,10) = 3.95$ in R_{11}

AND

$F_{.975}(10,7) = 4.76$ in R_{13}

(3) Press $\boxed{E}$ then $\boxed{x \gtrless t}$ to display

l = .2802414933 OR l = .2812939522

u = 5.358378288 OR u = 5.288888889

10. Find a 90% confidence interval for μ_Y/μ_X given the following data:

X: 17 6 12 14 3 12 15

Y: 7 15 4 6 21 13

SOLUTION:

(1) Enter data using DEI Sequence

(2) Store $(1+\gamma)/2 = .95$ in R_{09} OR $F_{.95}(12,14) = 2.55$ in R_{11}

AND

$F_{.95}(14,12) = 2.64$ in R_{13}

(3) Press $\boxed{E'}$ then $\boxed{x \gtrless t}$ to display

l = .3688954123 OR l = .3822288409

u = 2.472430016 OR u = 2.573164557

11. Two types of electric bulbs are observed as to length of life, yeilding the following results. Are the means significantly different? (α = .1)

Type 1 $n = 46$ $\bar{x} = 1070$

Type 2 $m = 64$ $\bar{y} = 1041$

SOLUTION:

(1) Press $\boxed{D}$ then store $n = 46$ in R_{15}, $m = 64$ in R_{03}, $\bar{x} = 1070$ in R_{18} and $\bar{y} = 1041$ in R_{08}

(2) Store $(1+\gamma)/2 = .95$ in R_{09} OR $F_{.95}(98,128) = 1.33$ in R_{11}

AND

$F_{.95}(128,98) = 1.40$ in R_{13}

(3) Press $\boxed{E'}$ then $\boxed{x \gtrless t}$ to display

$l = .7102715868$	OR	$l = .7315016513$
$u = 1.345613548$		$u = 1.362056075$

Thus with 90% confidence the means are not different.

PROGRAM 3 USER GUIDE - One-Population Hypothesis Tests

INTRODUCTION: The purpose of this program is to perform one-tailed or two-tailed hypothesis tests for the following one-population situations:

NORMAL	μ_o with σ^2 known
NORMAL	μ_o with σ^2 unknown
BERNOULLI	p_o
NORMAL	σ_o^2 with μ known
NORMAL	σ_o^2 with μ unknown
EXPONENTIAL	$\mu_o = 1/\lambda_o$
POISSON	λ_o

GENERAL PROCEDURES:

1. This program requires the Applied Statistics Module. After reading all three card edges, press $\boxed{E'}$ to repartition (719.29).

2. For each new problem press $\boxed{E'}$ to clear all registers and to prepare for the following parameter entries. Enter θ_o and press $\boxed{R/S}$, enter α and press $\boxed{R/S}$, then enter either 0, -1 or +1 for the desired alternate hypothesis, as in the table below, and press $\boxed{R/S}$.

0 for H_1: $\theta \neq \theta_o$, Two-tailed test

-1 for H_1: $\theta < \theta_o$, Lower-tailed test

+1 for H_1: $\theta > \theta_o$, Upper-tailed test

3. For data entry press $\boxed{D}$ followed by data point x_1, $\boxed{R/S}$, x_{i+1}, $\boxed{R/S}$, etc. for each x_i (i=1,2,...,n) until all data points have been entered. Mistakes in data entry should be corrected immediately by reentering the unwanted data point and pressing $\boxed{INV}$ $\boxed{2nd}$ $\boxed{\Sigma+}$, then enter the correct data point and press $\boxed{R/S}$ $\boxed{R/S}$. Alternate data entry using summary statistics is detailed in each subroutine.

4. At the conclusion of each test a 1 for Reject or a 0 for Accept is displayed. The significance level for each test is usually in the T-register (R_T); however, for two-tailed unsymmetric tests the test statistic stored in R_{12} is used as follows: if a 0 is displayed then the test must have failed to reject in both tails. If a 1 is displayed then the test was upper-tailed if R_{12} is greater than the median and lower-tailed if R_{12} is less than the median.

PROGRAM 3 SPECIFIC PROCEDURES:

Tests for NORMAL μ_o with σ^2 known

1. Press $\boxed{E'}$, enter μ_o, press $\boxed{R/S}$, enter α, press $\boxed{R/S}$, enter 0, -1 or +1 and press $\boxed{R/S}$.
2. Enter data using $\boxed{D}$ and store σ in R_{07} (Alternate entry: store n in R_{03}, $\bar{x}$ in R_{10} and σ in R_{07}).
3. Press $\boxed{A}$ either 1 (reject) or 0 (accept) is displayed, press $\boxed{x \gtrless t}$ to display significance level.

Tests for NORMAL μ_o with σ^2 unknown

1. Press $\boxed{E'}$, enter μ_o, press $\boxed{R/S}$, enter α, press $\boxed{R/S}$, enter 0, -1 or +1 and press $\boxed{R/S}$.
2. Enter data using $\boxed{D}$ (Alternate entry: store n in R_{03}, $\bar{x}$ in R_{10} and s_X in R_{14}).
3. $\boxed{C}$ either 1 (reject) or 0 (accept) is displayed, then press $\boxed{x \gtrless t}$ to display significance level.

Tests For Bernoulli p_o

1. Press $\boxed{E'}$, enter p_o, press $\boxed{R/S}$, enter α, press $\boxed{R/S}$, enter 0, -1 or +1 and press $\boxed{R/S}$.
2. Store $n\bar{x}$ in R_{01} and n in R_{03}.
3. Press $\boxed{B}$ either 1 (reject) or 0 (accept) is displayed, then press $\boxed{x \gtrless t}$ to display significance level.

Tests For NORMAL σ_o^2 with μ known

1. Press $\boxed{E'}$, enter σ_o^2, press $\boxed{R/S}$, enter α, press $\boxed{R/S}$, enter 0, -1 or +1 and press $\boxed{R/S}$.
2. Enter data using $\boxed{D}$ and store μ in R_{10} (Alternate entry: store n in R_{03}, $\sum x_i$ in R_{01}, $\sum x_i^2$ in R_{02} and μ in R_{10}).
3. Press $\boxed{D'}$ either 1 (reject) or 0 (accept) is displayed, then press $\boxed{x \gtrless t}$ to display significance level.

Tests For NORMAL σ_o^2 with μ unknown

1. Press $\boxed{E'}$, enter σ_o^2 , press $\boxed{R/S}$, enter α, press $\boxed{R/S}$, enter 0, -1 or +1 and press $\boxed{R/S}$.
2. Enter data using $\boxed{D}$ (Alternate entry: store n in R_{03} and $(n-1)s_X^2$ in R_{10}).
3. Press $\boxed{A'}$ either 1 (reject) or 0 (accept) is displayed, then press $\boxed{x \gtrless t}$ to display significance level.

Tests For EXPONENTIAL $\mu_o = 1/\lambda_o$

1. Press $\boxed{E'}$, enter μ_o, press $\boxed{R/S}$, enter α, press $\boxed{R/S}$, enter 0, -1 or +1 and press $\boxed{R/S}$.
2. Enter data using $\boxed{D}$ (Alternate: store n in R_{03} and $\bar{x}$ in R_{10}).
3. Press $\boxed{E}$ either 1 (reject) or 0 (accept) is displayed, then press $\boxed{x \gtrless t}$ to display significance level.

Tests For POISSON λ_o

1. Press $\boxed{E'}$, enter λ_o, press $\boxed{R/S}$, enter α, press $\boxed{R/S}$, enter 0, -1 or +1 and press $\boxed{R/S}$.
2. Enter data using $\boxed{D}$ (Alternate entry: store n in R_{03} and $n\bar{x}$ in R_{01}).
3. Press $\boxed{B'}$ either 1 (reject) or 0 (accept) is displayed, then press $\boxed{x \gtrless t}$ to display significance level.

PROGRAM 3 LABELS USED

A	A'	TAN	LNX
B	B'	SIN	LOG
C	C'	COS	INV
D	D'	CLR	FIX
E	E'	GRD	INT
×	+	SUM	ENG
÷	-	CE	

PROGRAM 3 STORAGE REGISTER CONTENTS

00	0, -1 or +1	10	$\bar{x}$ or μ or $(n-1)s_X^2$
01	$n\bar{x}$ or $\sum x_i$	11	α
02	$\sum x_i^2$	12	test statistic
03	n	13	clear
04	clear	14	s_X
05	clear	15-29	used
06	degrees of freedom		
07	σ		
08	μ_o or σ_o^2 or p_o or λ_o		
09	clear		

PROGRAM 3 SAMPLE PROBLEMS:

1. According to an early encyclopedia the average rainfall in a city is 30.1 inches. Rainfall during the past five years has been:

   30.5 27.4 35.1 32.6 25.9

   Assuming a standard deviation of .2 inches, has the average changed?

   SOLUTION: $H_0: \mu = 30.1$, $H_1: \mu \neq 30.1$, $\alpha = .05$

   (1) Press $\boxed{E'}$, 30.1, $\boxed{R/S}$, .05, $\boxed{R/S}$, 0, $\boxed{R/S}$.

   (2) Enter data using $\boxed{D}$, store $\sigma = .2$ in R_{07}

   (3) Press $\boxed{A}$ 1 is displayed (reject H_0),

   $\boxed{x \gtrless t}$ sl = .0253472347 .

2. A new fad diet was tried out on 15 subjects and the weight losses after one week were:

   2.07 2.34 1.97 1.85 1.84 2.23 2.15 1.89

   1.93 1.99 1.86 1.90 2.09 2.16 2.04

   An advertisement claims that the weight loss after one week on the diet is at least two pounds. Do the data support the claim?($\alpha = .05$)

   SOLUTION: $H_0: \mu \geq 2$, $H_1: \mu < 2$

   (1) Press $\boxed{E'}$, 2, $\boxed{R/S}$, .05, $\boxed{R/S}$, 1, $\boxed{R/S}$.

   (2) Enter data using $\boxed{D}$.

   (3) Press $\boxed{C}$ 0 is displayed (accept H_0),

   $\boxed{x \gtrless t}$ sl = .302539836 .

3. It is claimed that a certain drug will lower temperature within ten minutes. Five subjects having normal temperatures of 98.6 were given the drug and ten minutes later their temperatures were recorded in summary form as follows: $\sum x = 491$, $\sum x^2 = 48219$. Test the claim at the $\alpha = .05$ level.

SOLUTION: $H_o: \mu \leq 98.6$, $H_1: \mu > 98.6$

(1) Press $\boxed{E'}$, 98.6, $\boxed{R/S}$, .05, $\boxed{R/S}$, -1, $\boxed{R/S}$.

(2) Store $n = 5$ in R_{03}, $\bar{x} = 491/5$ in R_{10} and $s_X = \frac{48219-5\bar{x}^2}{4}$ in R_{14}

(3) Press $\boxed{C}$ 0 is displayed (accept H_o),

$\boxed{x \gtrless t}$ sl = .1352267548 .

4. A student claims he can always answer more than half of the items on a true-false exam correctly, regardless of the topic. You devise a 20 question exam on a subject of which he knows nothing and he answers 12 of the test items correctly. Would you conclude he has extraordinary powers? ($\alpha = .05$)

SOLUTION: $H_o: \mu = .5$, $H_1: \mu > .5$

(1) Press $\boxed{E'}$, .5, $\boxed{R/S}$, .05, $\boxed{R/S}$, 1, $\boxed{R/S}$.

(2) Store $n\bar{x} = 12$ in R_{01} and $n = 20$ in R_{03}.

(3) Press $\boxed{B}$ 0 is displayed (accept H_o),

$\boxed{x \gtrless t}$ sl = .2517223358 .

5. Of 694 respondents, 369 were in favor of more dissemination of birth control information. Is it safe to conclude that more than half of the population agrees with this position? ($\alpha = .05$)

SOLUTION: $H_o: \mu \leq .5$, $H_1: \mu > .5$

(1) Press $\boxed{E'}$, .5, $\boxed{R/S}$, .05, $\boxed{R/S}$, 1, $\boxed{R/S}$.

(2) Store $n\bar{x} = 369$ in R_{01} and $n = 694$ in R_{03}

(3) Press $\boxed{B}$ 1 is displayed (reject H_o),

$\boxed{x \gtrless t}$ sl = .0474381802 .

6. A soup can filling machine is supposed to fill each can with ten ounces of clear broth, with a variance of .01. A change in variability in either direction is undesirable. A random sample of 20 cans yeilded $\sum x^2 = 2107.7$ and $\sum x = 205.3$. Is the machine working within limits? ($\alpha = .05$)

<u>SOLUTION:</u> $H_o: \sigma^2 = .01$, $H_1: \sigma^2 \neq .01$

(1) Press $\boxed{E'}$, .01, $\boxed{R/S}$, .05, $\boxed{R/S}$, 0, $\boxed{R/S}$.

(2) Store n = 20 in R_{03}, $\sum x = 205.3$ in R_{01}, $\sum x^2 = 2107.7$ in R_{02} and $\mu = 10$ in R_{10}

(3) Press $\boxed{D'}$ 1 is displayed (reject H_o).

7. A nail machine is supposed to manfacture 1-inch nails with a standard deviation of .025 inches. A random sample of 30 nails yeilded a sample value for s_X of .03 inches. Does this apparent increase warrant shutting the machine down? ($\alpha = .05$)

<u>SOLUTION:</u> $H_o: \sigma^2 \leq (.025)^2$, $H_1: \sigma^2 > (.025)^2$

(1) Press $\boxed{E'}$, .000625, $\boxed{R/S}$, .05, $\boxed{R/S}$, 1, $\boxed{R/S}$.

(2) Store n = 30 in R_{03} and $(n-1)s^2 = 29(.03)^2$ in R_{10}

(3) Press $\boxed{A'}$ 0 is displayed (accept H_o)

$\boxed{x \gtrless t}$ sl = .059

8. A certain type of expensive electrical gear is supposed to have a mean life of 1000 hours. The manfacturer is concerned if the mean departs in either direction from 1000. Five components were tested and they had the following burnout times:

1075 1085 1060 998 995

Is the mean still 1000? ($\alpha = .05$)

SOLUTION: H_o: $\mu = 1000$, H_1: $\mu \neq 1000$

(1) Press $\boxed{E'}$, 1000, $\boxed{R/S}$, .05, $\boxed{R/S}$, 0, $\boxed{R/S}$.

(2) Enter data using $\boxed{D}$

(3) Press $\boxed{E}$ 0 is displayed (accept H_o)

9. Over a period of years there had been an average of 14 accidents per year in a certain city. This year the monthly totals were as follows: 1 0 2 2 1 1 3 0 1 0 1 2 .
Does this data agree with the theory that the number of accidents per month follows a poisson distribution with $\lambda = 1.1667$? ($\alpha = .05$)

SOLUTION: H_o: $\lambda = 1.1667$, H_1: $\lambda \neq 1.1667$

(1) Press $\boxed{E'}$, 1.1667, $\boxed{R/S}$, .05, $\boxed{R/S}$, 0, $\boxed{R/S}$.

(2) Enter data using $\boxed{D}$

(3) Press $\boxed{B'}$ 0 is displayed (accept H_o)

$\boxed{x \gtrless t}$ sl = .5703943172

PROGRAM 4 USER GUIDE - Two-Population Hypothesis Tests

INTRODUCTION: The purpose of this program is to perform one-tailed and two-tailed hypothesis tests for the following two-population situations.

BERNOULLI	$p_X = p_Y$	for large sample sizes
NORMAL	$\mu_X = \mu_Y$	for X and Y paired
NORMAL	$\mu_X = \mu_Y$	for X and Y independent with $\sigma_X^2 = \sigma_Y^2 = \sigma^2$
NORMAL	$\mu_X = \mu_Y$	for X and Y independent with σ_X^2, σ_Y^2 known
NORMAL	$\mu_X = \mu_Y$	for X and Y independent with $\sigma_X^2 \neq \sigma_Y^2$
NORMAL	$\sigma_X^2 = \sigma_Y^2$	for X and Y independent
NORMAL	$\rho = 0$	for X and Y paired
EXPONENTIAL	$\lambda_X = \lambda_Y$	for X and Y independent

GENERAL PROCEDURES:

1. This program requires the Applied Statistics Module. After reading all three card edges, press $\boxed{E'}$ to repartition (719.29).

2. For each new problem press $\boxed{E'}$ to clear all registers and to prepare for the following parameter entries. Enter α and press $\boxed{R/S}$ then enter either 0, -1 or +1 for the desired alternate hypothesis, as in the table below, and press $\boxed{R/S}$.

   0 for H_1: $\theta_X \neq \theta_Y$, Two-tailed test

   -1 for H_1: $\theta_X < \theta_Y$, Lower-tailed test

   +1 for H_1: $\theta_X > \theta_Y$, Upper-tailed test

3. For independent data entry (DEI Sequence) press $\boxed{D}$ followed by data point x_i, $\boxed{R/S}$, x_{i+1}, $\boxed{R/S}$, etc. for each x_i $(i=1,2,\ldots,n)$. When all x_i's have been entered press $\boxed{D}$ again, followed by data point y_i, $\boxed{R/S}$, y_{i+1}, $\boxed{R/S}$, etc. for each y_i $(i=1,2,\ldots,m)$. when all of the y_i's have been entered press $\boxed{D}$. Mistakes in data entry should be

corrected immediately by reentering the unwanted data point and pressing $\boxed{\text{INV}}$ $\boxed{\text{2nd}}$ $\boxed{\Sigma +}$, then enter the correct data point and press $\boxed{\text{R/S}}$ $\boxed{\text{R/S}}$. Alternate data entry is detailed in each subroutine.

4. For paired data entry (DEP Sequence) press $\boxed{\text{D}}$ followed by x_i, $\boxed{x\gtrless t}$, y_i $\boxed{\text{R/S}}$, x_{i+1}, $\boxed{x\gtrless t}$, y_{i+1}, $\boxed{\text{R/S}}$, etc. when all of the paired data points have been entered press $\boxed{\text{SBR}}$ $\boxed{\text{RST}}$. Mistakes and alternate entry are as above.

5. Each routine displays either a 1 for Reject or a 0 for Accept. The significance level is always in the T-register (R_T).

<u>PROGRAM 4 SPECIFIC PROCEDURES</u>:

<u>Tests for BERNOULLI</u> $p_X=p_Y$ <u>for large sample sizes</u>

1. Press $\boxed{\text{E'}}$, enter α, press $\boxed{\text{R/S}}$, enter 0, -1 or +1, and press $\boxed{\text{R/S}}$.
2. Store n in R_{15}, $n\bar{x}$ in R_{04}, m in R_{03} and $m\bar{y}$ in R_{01}.
3. Press $\boxed{\text{B}}$ either 1 (reject) or 0 (accept) is displayed, then press $\boxed{x\gtrless t}$ to display significance level.

<u>Tests for NORMAL $\mu_X = \mu_Y$ for X and Y paired</u>

1. Press $\boxed{\text{E'}}$, enter α, press $\boxed{\text{R/S}}$, enter 0, -1 or +1 and then press $\boxed{\text{R/S}}$.
2. Enter data using DEP Sequence (Alternate entry: store (n-1) in R_{25} and $\bar{d}(\sqrt{n}/s_d)$ in R_{10})
3. Press $\boxed{\text{B'}}$ either 1 (reject) or 0 (accept) is displayed, then press $\boxed{x\gtrless t}$ to display significance level.

Tests for NORMAL $\mu_X = \mu_Y$ with $\sigma_X^2 = \sigma_Y^2 = \sigma^2$

1. Press $\boxed{E'}$, enter α, press $\boxed{R/S}$, enter 0 , -1 or +1 and then press $\boxed{R/S}$.
2. Enter data using DEI Sequence (Alternate entry: store n in R_{15}, m in R_{03}, $\bar{x}$ in R_{14}, $\bar{y}$ in R_{08}, s_X^2 in R_{09} and s_Y^2 in R_{07})
3. Press $\boxed{C}$ either 1 (reject) or 0 (accept) is displayed, then press $\boxed{x \gtrless t}$ to display significance level.

Tests for NORMAL $\mu_X = \mu_Y$ for σ_X^2 and σ_Y^2 known

1. Press $\boxed{E'}$, enter α, press $\boxed{R/S}$, enter 0, -1 or +1 and then press $\boxed{R/S}$.
2. Enter data using DEI Sequence and store σ_X^2 in R_{09} and σ_Y^2 in R_{07} (Alternate entry: store n in R_{15}, m in R_{03}, $\bar{x}$ in R_{14}, $\bar{y}$ in R_{08}, σ_X^2 in R_{09} and σ_Y^2 in R_{07})
3. Press $\boxed{A}$ either 1 (reject) or 0 (accept) is displayed, then press $\boxed{x \gtrless t}$ to display significance level.

Tests for NORMAL $\mu_X = \mu_Y$ for $\sigma_X^2 \neq \sigma_Y^2$

1. Press $\boxed{E'}$, enter α, press $\boxed{R/S}$, enter 0, -1 or +1 and then press $\boxed{R/S}$.
2. Enter data using DEI Sequence (Alternate entry: store n in R_{15}, m in R_{03}, $\bar{x}$ in R_{14}, $\bar{y}$ in R_{08}, s_X^2 in R_{09} and s_Y^2 in R_{07}).
3. Press $\boxed{C'}$, 1 (reject) or 0 (accept) is displayed, then press $\boxed{x \gtrless t}$ to display significance level.

Tests for NORMAL $\sigma_X^2 = \sigma_Y^2$

1. Press $\boxed{E'}$, enter α, press $\boxed{R/S}$, enter 0, -1 or +1 and then press $\boxed{R/S}$.
2. Enter data using DEI Sequence (Alternate entry: store n in R_{15}, m in R_{03}, s_X^2 in R_{09} and s_Y^2 in R_{07}).
3. Press $\boxed{D'}$ either 1 (reject) or 0 (accept) is displayed, then press $\boxed{x \gtrless t}$ to display significance level.

Tests for NORMAL $\rho = 0$

1. Press $\boxed{E'}$, enter α, press $\boxed{R/S}$, enter 0, -1 or +1 and then press $\boxed{R/S}$.
2. Enter data using DEP Sequence (no alternate entry).
3. Press $\boxed{A'}$ either 1 (reject) or 0 (accept) is displayed, then press $\boxed{x \gtrless t}$ to display significance level.

Tests for EXPONENTIAL $\lambda_X = \lambda_Y$

1. Press $\boxed{E'}$, enter α, press $\boxed{R/S}$, enter 0, -1 or +1 and then press $\boxed{R/S}$.
2. Enter data using DEI Sequence (Alternate entry: store n in R_{15}, m in R_{03}, $\bar{x}$ in R_{14} and $\bar{y}$ in R_{08}).
3. Press $\boxed{E}$ either 1 (reject) or 0 (accept) is displayed, then press $\boxed{x \gtrless t}$ to display significance level.

PROGRAM 4 LABELS USED

A	A'	SIN	RST	GTO
B	B'	COS	CLR	x^2
C	C'	DEG	RCL	+
D	D'	INV	STO	-
E	E'	GRD	EXC	

PROGRAM 4 STORAGE REGISTER CONTENTS:

00	0, -1 or +1	07	s_Y^2 or σ_Y^2	14	$\bar{x}$
01	$m\bar{y}$ or $\sum y$	08	$\bar{y}$	15	n
02	$\sum y^2$	09	s_X^2 or σ_X^2	16 - 24	used
03	m or n	10	$\bar{d}(\sqrt{n}/s_d)$	25	(n-1)
04	$n\bar{x}$ or $\sum x$	11	α	26 - 29	used
05	$\sum x^2$	12	used		
06	$\sum xy$	13	used		

PROGRAM 4 SAMPLE PROBLEMS:

1. According to last year,s statistics, 70% of the population were in favor of stricter smog control laws. This year only 65% of 1000 respondents favored stricter laws. Does this represent a significant decrease? (α = .01)

   SOLUTION: H_o: $p_X = p_Y$, H_1: $p_X > p_Y$

   (1) Press $\boxed{E'}$, .01, $\boxed{R/S}$, +1, $\boxed{R/S}$.

   (2) Store n = 1000 in R_{15}, $n\bar{x}$ = 700 in R_{04}, m = 1000 in R_{03} and $m\bar{y}$ = 650 in R_{01}.

   (3) Press $\boxed{B}$ 1 is displayed (reject H_o)

   $\boxed{x \rightleftarrows t}$ sl = .0084920904

2. Ten plots are split and half planted with variety A and half with variety B. The yields are shown below. Is there a difference in mean yield between the two varieties? (α = .10)

A:	49	58	53	60	45	49	66	55	44	52
B:	47	57	49	57	44	44	67	52	42	53

   SOLUTION: H_o: $\mu_A = \mu_B$, H_1 $\mu_A \neq \mu_B$

   (1) Press $\boxed{E'}$, .10, $\boxed{R/S}$, 0, $\boxed{R/S}$.

(2) Enter data using DEP Sequence.

(3) Press $\boxed{B'}$ 1 is displayed (reject H_o)

$\boxed{x \gtrless t}$ sl = .0137674905

3. A cigarette manufacturer tests tobacco from two different brands for nicotine content and obtains the following (in milligrams).

A:	24	26	25	22	23
B:	27	28	25	29	26

Do these results indicate there is a difference in mean nicotine content for the two brands? ($\alpha = .05$)

SOLUTION: $H_o: \mu_A = \mu_B$, $H_1: \mu_A \neq \mu_B$

(1) Press $\boxed{E'}$, .05, $\boxed{R/S}$, 0, $\boxed{R/S}$.

(2) Enter data using DEI Sequence.

(3) Press $\boxed{C}$ 1 is displayed (reject H_o)

$\boxed{x \gtrless t}$ sl = .0170716812

4. Two analysts make fifty independent determinations of the melting point of a certain chemical. The sample mean and variance of the data found by analyst I are respectively, 73.6 and 10 while the sample mean and variance found by analyst II are, respectively, 72.4 and 8 . It is argued that there is a tendency for analyst I to get higher results. What is your conclusion? ($\alpha = .05$)

SOLUTION: $H_o: \mu_X = \mu_Y$, $H_1: \mu_X > \mu_Y$

(1) Press $\boxed{E'}$, .05, $\boxed{R/S}$, 1, $\boxed{R/S}$.

(2) Store n = 50 in R_{15}, m = 50 in R_{03}, $\bar{x} = 73.6$ in R_{14}, $\bar{y} = 72.4$ in R_{08}, $s_X^2 = 10$ in R_{09} and $s_Y^2 = 8$ in R_{07}.

(3) Press $\boxed{C}$ 1 is displayed (reject H_o)

$\boxed{x \gtrless t}$ sl = .022750062

5. We are interested in replacing wire B with wire A if the resistance per unit length is not significantly decreased. The results of twenty tests on each wire are presented below. If we know that the standard deviation of the two testing procedures are both .0017 ohms. What is your recommendation? (α = .01)

A	.051	.051	.049	.048	.049	.049	.049	.053	.053	.049
	.049	.047	.048	.049	.049	.051	.051	.050	.047	.050
B	.054	.052	.051	.049	.051	.057	.054	.052	.050	.052
	.051	.051	.055	.049	.052	.051	.051	.052	.052	.048

SOLUTION: H_o: $\mu_A \leq \mu_B$, H_1: $\mu_A > \mu_B$.

(1) Press $\boxed{E'}$, .01, $\boxed{R/S}$, 1, $\boxed{R/S}$.

(2) Enter data using DEI Sequence and store $\sigma_X^2 = (.0017)^2$ in R_{09} and $\sigma_Y^2 = (.0017)^2$ in R_{07}

(3) Press $\boxed{A}$ 0 is displayed (accept H_o)

$\boxed{x \rightleftarrows t}$ sl = .500837784

6. Twenty plots of ground were planted with corn. Ten plots (Y) contained a special treatment. The variances were tested and found to be unequal. Is there a significant difference between the yields at the 5% level?

$\bar{x} = 6.1$ $\quad\quad$ $\bar{y} = 5.78$

$s_X^2 = .13556$ $\quad\quad$ $s_Y^2 = .02844$

SOLUTION: H_o: $\mu_X = \mu_Y$, H_1: $\mu_X \neq \mu_Y$.

(1) Press $\boxed{E'}$, .05, $\boxed{R/S}$, 0, $\boxed{R/S}$

(2) Store n = 10 in R_{15}, m = 10 in R_{03}, $\bar{x} = 6.1$ in R_{14}, $\bar{y} = 5.78$ in R_{08}, $s_X^2 = .13556$ in R_{09} and $s_Y^2 = .02844$ in R_{07}.

(3) Press $\boxed{C'}$ 1 is displayed (reject H_o)

$\boxed{x \rightleftarrows t}$ sl = .026650012

7. Suppose that two samples of ten and sixteen observations have, respectively, variances of .3888 and 2.25 . At the 5% significance level would you accept the hypothesis that $\sigma_1^2 \leq \sigma_2^2$?

SOLUTION: H_o: $\sigma_X^2 \leq \sigma_Y^2$, H_1: $\sigma_X^2 > \sigma_Y^2$.

(1) Press $\boxed{E'}$, .05, $\boxed{R/S}$, -1, $\boxed{R/S}$.

(2) Store n = 10 in R_{15}, m = 16 in R_{03}, s_X^2 = .3888 in R_{09} and s_Y^2 = 2.25 in R_{07}.

(3) $\boxed{D'}$ 0 is displayed (accept H_o)

$\boxed{x \gtrless t}$ sl = .994190704 .

8. The following data measurements of students' ability in an IQ test are paired with scores in an acheivement test. Test for $\rho = 0$.

X:	105	95	125	92	120	107	121	90	132	116
Y:	47	46	53	31	64	43	75	40	80	55

SOLUTION: H_o: $\rho = 0$, H_1: $\rho \neq 0$

(1) Press $\boxed{E'}$, .05, $\boxed{R/S}$, 0, $\boxed{R/S}$.

(2) Enter data using DEP Sequence

(3) Press $\boxed{A'}$ 1 is displayed (reject H_o)

$\boxed{x \gtrless t}$ sl = .0012735515

9. Two types of electric bulbs are observed as to length of life, with the following results: n = 46, m = 64, $\bar{x}$ = 1070 and $\bar{y}$ = 1041. Are the mean lives significantly different? (α = .10)

SOLUTION: H_o: $\lambda_X = \lambda_Y$, H_1: $\lambda_X \neq \lambda_Y$

(1) Press $\boxed{E'}$, .1, $\boxed{R/S}$, 0, $\boxed{R/S}$.

(2) Store n = 46 in R_{15}, m = 64 in R_{03}, $\bar{x}$ = 1070 in R_{14} and $\bar{y}$ = 1041 in R_{08} .

(3) $\boxed{E}$ 0 is displayed (accept H_o)

$\boxed{x \gtrless t}$ sl = .5605970415

USER GUIDE FOR FIVE DISTRIBUTION PROGRAMS

INTRODUCTION: The purpose of these five programs is to provide accurate approximate values for the following distributions: Normal, Binomial/Multinomial, Chi-square, Student's t , and F .

GENERAL PROCEDURES: Read in the appropriate program and proceed as below.

NORMAL Distribution - Program 5

Proceed with the following steps in any order.

	Enter	Press	Display
1.	z	A	$\phi(z)$ = normal density at z
2.	z	B	$P(z) = P(Z \leq z)$
3.	P(z)	C	z_p = normal p^{th} percentile
4.	z	D	$Q(z) = P(Z > z)$
5.	z	E	$A(z) = P(Z \leq \|z\|)$

BINOMIAL Distribution - Program 6

Perform the first two steps and then do the remaining steps in any order.

	Enter	Press	Display
1.	n	A	n
2.	p	B	p
3.	k	C	$f(k;n,p)$ = binomial density at k
4.	k	D	$F(k;n,p) = P(Z \leq k)$
5.	k	E	$Q(k) = P(Z > k)$
6.	-	A'	μ
7.	-	B'	σ

MULTINOMIAL Density - Program 6

Perform the following steps in order. Step 2 must be completed for each set (n_i, p_i) for $i=1,2,\ldots,k$. $(k \leq 35)$

	Enter	Press	Display
1.	N	$\boxed{C'}$	-
2.	n_i	$\boxed{x \rightleftarrows t}$	$\sum n_i$ (can be used to check $\sum n_i = N$)
	p_i	$\boxed{R/S}$	$\sum p_i$ (can be used to check $\sum p_i = 1$)
3.	-	$\boxed{D'}$	$f(n_1, n_2, \ldots, n_k)$

* As an added feature the following capability exists in Program 6.

4. Store N in R_{07} and press $\boxed{E'}$ to display $N!$ $(N \leq 69)$.

CHI-SQUARE Distribution - Program 7

Store v in R_{15} and then the following steps in any order.

	Enter	Press	Display
1.	χ^2	$\boxed{A}$	$f(\chi^2)$ = density at χ^2
2.	χ^2	$\boxed{B}$	$P(\chi^2) = P(Z \geq \chi^2)$
3.	$P(\chi^2)$	$\boxed{C}$	$\chi^2_p(v) = p^{th}$ percentile

* As an added feature the Gamma function can be evaluated as below.

4.	v	$\boxed{D}$	$\Gamma(v/2)$

STUDENT'S t Distribution - Program 8

Store v in R_{15} and then the following steps in any order.

	Enter	Press	Display
1.	t	$\boxed{A}$	$f(t)$ = density at t
2.	t	$\boxed{B}$	$P(t) = P(Z \geq t)$
3.	$P(t)$	$\boxed{C}$	$t_p(v) = p^{th}$ percentile

* As an added feature the Gamma function can be evaluated as below.

5. Store v in R_{15} and press $\boxed{D}$ to display $\Gamma(v/2)$.

F Distribution - Program 9

Complete Steps 1 and 2 prior to Steps 3 or 4 below.

	Enter	Press	Display
1.	v_1	$\boxed{x \gtrless t}$	-
2.	v_2	$\boxed{A}$	-
3.	$F(v_1, v_2)$	$\boxed{B}$	$P(F) = P(Z \geq F)$
4.	$P(F)$	$\boxed{C}$	$F_p(v_1, v_2) = p^{th}$ percentile

PROGRAM 5 LABELS USED

A B C D E D' E'

PROGRAM 6 LABELS USED

A B C D E A' B' C' D' E'

PROGRAM 7 LABELS USED

A B C D E A' B' C' D' E'

PROGRAM 8 LABELS USED

A B C D E B' C' E'

PROGRAM 9 LABELS USED

A B C D E A' B' C' D' E'

PROGRAM 5 REGISTERS USED

9 11 25 26 29

PROGRAM 6 REGISTERS USED - ALL

PROGRAM 7 REGISTERS USED

01 09 10 11 13 14 15 17 thru 23

PROGRAM 8 REGISTERS USED

00 02 09 10 15 thru 24

PROGRAM 9 REGISTERS USED

00 02 08 09 11 15 thru 29

PROGRAM 5 - Sample Problems

1. Find $\Phi(1.960)$.

   SOLUTION:

   Enter 1.960 and press $\boxed{A}$, .0584409443 is displayed

2. Find $P(1.960) = P(Z \leq 1.960)$

   SOLUTION:

   Enter 1.960 and press $\boxed{B}$, .9750021748 is displayed

3. Find $P(-1.960)$.

   SOLUTION:

   Enter -1.960 and press $\boxed{B}$, .0249978252 is displayed.

4. Find $z_{.05}$

   SOLUTION:

   Enter .05 and press $\boxed{C}$, -1.64521144 is displayed.

5. Find $z_{.95}$

   SOLUTION:

   Enter .95 and press $\boxed{C}$, 1.64521144 is displayed.

6. Find $Q(1.282) = P(Z > 1.282)$

   SOLUTION:

   Enter 1.282 and press $\boxed{D}$, .0999213886 is displayed.

7. Find $A(1.282) = P(Z \leq |z|)$

   SOLUTION:

   Enter 1.282 and Press $\boxed{E}$, .8001572228 is displayed.

PROGRAM 6 SAMPLE PORBLEMS

1. Find f(k;n,p) given k = 6, n = 10 and p = .4 .

SOLUTION:

Enter 10 press [A] then enter .4 press [B] then enter 6 press [C], .111476736 is displayed.

2. Find P(8) when n = 10 and p = .75 .

SOLUTION:

Enter 10 press [A] then enter .75 press [B] then enter 8 press [D], .7559747696 is displayed.

3. Find Q(2) when n = 10 and p = .25 .

SOLUTION:

Enter 10 press [A] then enter .25 press [B] then enter 2 press [E], .474407196 is displayed.

4. Find μ and σ for a Binomial distribution with n = 20 and p = .5 .

SOLUTION:

Enter 20 press [A] then enter .5 press [B] then press [A'] μ = 10 is displayed, then press [B'] σ^2 = 2.236067977 is displayed.

5. Find $f(n_i)$ for the following Multinomial case.

n_i	1	2	3	4
p_i	.4	.3	.2	.1

SOLUTION:

Enter 10 press [C'] then enter n_i [x⇄t] p_i [R/S] etc. and press [D'] , .00036288 is displayed.

PROGRAM 7 Sample Problems

1. Find f(25) where v = 15.

SOLUTION:

Store 15 in R_{15} , then enter 25 and press $\boxed{A}$

.0134298528 is displayed.

2. Find P(25) where v = 15.

SOLUTION:

Store 15 in R_{15} , then enter 25 and press $\boxed{B}$

.9500565664 is displayed.

3. Find $\chi^2_{.99}(16)$.

SOLUTION:

Store 16 in R_{15} , then enter .99 and press $\boxed{C}$

31.99987803 is displayed.

4. Find $\Gamma(8)$.

SOLUTION:

Enter 16 press $\boxed{D}$, 5040 is displayed.

PROGRAM 8 Sample Problems

1. Find f(2) where v = 20.

SOLUTION:

Store 20 in R_{15} , then enter 2 and press $\boxed{A}$

.0580872152 is displayed.

2. Find P(-.860) where v = 20.

SOLUTION:

Store 20 in R_{15} , then enter -.860 and press $\boxed{B}$

.199990431 is displayed.

3. Find $t_{.90}(14)$.

SOLUTION:

Store 14 in R_{15}, then enter .90 and press $\boxed{C}$

1.345266653 is displayed.

4. Find $\Gamma(4.5)$.

SOLUTION:

Store 9 in R_{15}, then press $\boxed{D}$

11.6317284 is displayed.

PROGRAM 9 - Sample Problems

1. Find P(2.52) where $v_1 = 5$ and $v_2 = 10$.

SOLUTION:

Enter 5 and press $\boxed{x \gtrless t}$, then enter 10 and press $\boxed{A}$ enter 2.52 and press $\boxed{B}$, .8998498088 is displayed.

2. Find P(.397) where $v_1 = 10$ and $v_2 = 5$.

SOLUTION:

Enter 10 and press $\boxed{x \gtrless t}$, then enter 5 and press $\boxed{A}$ enter .397 and press $\boxed{B}$, .1002517964 is displayed.

3. Find $F_{.975}(10,30)$.

SOLUTION:

Enter 10 and press $\boxed{x \gtrless t}$, then enter 30 and press $\boxed{A}$ enter .975 and press $\boxed{C}$, 2.511201637 is displayed.

APPENDIX B

SELECTED CHI-SQUARE INVERSE CDF APPROXIMATIONS

	DEGREES OF FREEDOM	TABLED VALUE*	TYPE I APPROXIMATE PERCENTILE	TYPE I ACTUAL PROBABILITY	TYPE II APPROXIMATE PERCENTILE	TYPE II ACTUAL PROBABILITY
$\chi^2_{.05}$	1	.0039	.0000	.0001	.0039	.0499
	2	.1026	.0789	.0387	.1026	.0500
	3	.352	.3280	.0453	.3531	.0503
	4	.711	.6900	.0474	.7115	.0501
	5	1.15	1.1277	.0484	1.1460	.0500
	10	3.94	3.9307	.0496	3.9404	.0500
	15	7.26	7.2543	.0498	7.2610	.0500
	20	10.85	10.8455	.0499	10.8508	.0500
	30	18.49	18.4885	.0499	18.4927	.0500
	40	26.51	26.5056	.0499	same as TYPE I	
	60	43.19	43.1843	.0500	" " "	
	120	95.70	95.6999	.0500	" " "	
$\chi^2_{.90}$	1	2.71	2.6395	.8958	2.7067	.9001
	2	4.61	4.5596	.8977	4.6052	.9000
	3	6.25	6.2146	.8984	6.2517	.9000
	4	7.78	7.7480	.8987	7.7797	.9000
	5	9.24	9.2086	.8990	9.2366	.9000
	10	15.99	15.9688	.8995	15.9873	.9000
	15	22.31	22.2930	.8997	22.3072	.9000
	20	28.41	28.4003	.8997	28.4120	.9000
	30	40.26	40.2473	.8998	40.2560	.9000
	40	51.81	51.7981	.8999	same as TYPE I	
	60	74.40	74.3923	.8999	" " "	
	120	140.23	140.2309	.9000	" " "	
$\chi^2_{.995}$	1	7.88	7.9071	.9951	7.8815	.9950
	2	10.60	10.6753	.9952	10.5966	.9950
	3	12.84	12.9227	.9952	12.8377	.9950
	4	14.86	14.9437	.9952	14.8602	.9950
	5	16.75	16.8303	.9952	16.7497	.9950
	10	25.19	25.2557	.9951	25.1884	.9950
	15	32.80	32.8604	.9951	32.8015	.9950
	20	40.00	40.0502	.9951	39.9970	.9950
	30	53.67	53.7181	.9951	53.6721	.9950
	40	66.77	66.8076	.9950	same as TYPE I	
	60	91.95	91.9879	.9950	" " "	
	120	163.64	163.6777	.9950	" " "	

* [Ref. 2: p. 465]

SELECTED STUDENT'S t INVERSE CDF APPROXIMATIONS

DEGREES OF FREEDOM		TABLED VALUE*	TYPE I APPROXIMATE PERCENTILE	TYPE I ACTUAL PROBABILITY	TYPE II APPROXIMATE PERCENTILE	TYPE II ACTUAL PROBABILITY
$t_{.60}$	1	.325	.2568	.5800	.3249	.6000
	2	.289	.2593	.5902	.2869	.5994
	3	.277	.2556	.5926	.2754	.5996
	4	.271	.2547	.5942	.2699	.5997
	5	.267	.2542	.5953	.2667	.5999
	10	.260	.2535	.5975	.2660	.5999
	15	.258	.2533	.5983	.2578	.6000
	20	.257	.2532	.5987	.2567	.6000
	30	.256	.2531	.5990	.2556	.6000
	40	.255	.2531	.5992	.2550	.6000
	60	.254	.2530	.5994	.2545	.6000
	120	.254	.2530	.5996	.2539	.6000
$t_{.90}$	1	3.078	1.7878	.8377	3.0777	.9000
	2	1.886	2.1065	.9151	1.8764	.8993
	3	1.638	1.6292	.8991	1.6383	.9001
	4	1.533	1.5092	.8971	1.5347	.9002
	5	1.476	1.4420	.8969	1.4772	.9002
	10	1.372	1.3581	.8979	1.3726	.9001
	15	1.341	1.3311	.8985	1.3408	.9000
	20	1.325	1.3182	.8988	1.3255	.9000
	30	1.310	1.3057	.8992	1.3105	.9000
	40	1.303	1.2996	.8994	1.3031	.9000
	60	1.296	1.2936	.8996	1.2958	.9000
	120	1.289	1.2876	.8998	1.2886	.9000
$t_{.995}$	1	63.657	6.6860	.9527	63.6567	.9950
	2	9.925	9.2732	.9943	9.7472	.9948
	3	5.841	5.3978	.9938	5.8223	.9950
	4	4.604	4.4230	.9943	4.5990	.9950
	5	4.032	3.9585	.9946	4.0299	.9950
	10	3.169	3.1961	.9952	3.1702	.9950
	15	2.947	2.9771	.9953	2.9476	.9950
	20	2.845	2.8726	.9953	2.8460	.9950
	30	2.750	2.7712	.9953	2.7504	.9950
	40	2.704	2.7215	.9952	2.7047	.9950
	60	2.660	2.6724	.9952	2.6604	.9950
	120	2.617	2.6240	.9951	2.6175	.9950

* [Ref. 2: p. 464]

SELECTED F INVERSE CDF APPROXIMATIONS

DEGREES OF FREEDOM			TABLED VALUE*	TYPE I APPROXIMATE PERCENTILE	TYPE I ACTUAL PROBABILITY	TYPE II APPROXIMATE PERCENTILE	TYPE II ACTUAL PROBABILITY
	v_1	v_2					
$F_{.05}$	1	1	.0062	-	-	.00619	.0500
		2	.0050	-	-	.00392	.0443
		5	.0043	-	-	.00391	.0475
		15	.0041	-	-	.00391	.0490
		30	.0040	-	-	.00391	.0495
		120	.0039	-	-	.00391	.0498
$F_{.05}$	5	1	.151	-	-	.1515	.0501
		2	.173	.1340	.0315	.1611	.0442
		5	.198	.1949	.0495	.1980	.0500
		15	.216	.2110	.0474	.2165	.0500
		30	.222	.2157	.0469	.2223	.0500
		120	.227	.2195	.0464	.2272	.0499
$F_{.05}$	15	1	.220	-	-	.2190	.0495
		2	.272	.2054	.0235	.2435	.0378
		5	.345	.3432	.0489	.3446	.0500
		15	.416	.4157	.0498	.4161	.0500
		30	.445	.4442	.0496	.4451	.0500
		120	.473	.4713	.0492	.4730	.0500
$F_{.05}$	30	1	.240	-	-	.2388	.0496
		2	.302	.2260	.0207	.2671	.0354
		5	.395	.3909	.0483	.3945	.0499
		15	.496	.4962	.0499	.4963	.0500
		30	.543	.5431	.0499	.5432	.0500
		120	.594	.5935	.0497	.5940	.0500
$F_{.05}$	120	1	.255	-	-	.2547	.0498
		2	.326	.2421	.0184	.2855	.0332
		5	.437	.4310	.0474	.4364	.0498
		15	.571	.5705	.0496	.5713	.0500
		30	.644	.6431	.0499	.6434	.0500
		120	.740	.7397	.0500	.7397	.0500

* [Ref. 2: pp. 472-485]

SELECTED F INVERSE CDF APPROXIMATIONS

DEGREES OF FREEDOM			TABLED VALUE*	TYPE I APPROXIMATE PERCENTILE	TYPE I ACTUAL PROBABILITY	TYPE II APPROXIMATE PERCENTILE	TYPE II ACTUAL PROBABILITY
	v_1	v_2					
$F_{.995}$	1	1	16200	-	-	16210.7	.9950
		2	198	-	-	135.65	.9925
		5	22.8	-	-	21.125	.9941
		15	10.8	-	-	11.063	.9954
		30	9.18	-	-	9.361	.9954
		120	8.18	-	-	8.233	.9951
$F_{.995}$	5	1	23100	-	-	25615.1	.9953
		2	199	554.13	.9982	276.56	.9964
		5	14.9	15.872	.9956	15.008	.9951
		15	5.37	5.409	.9951	5.373	.9950
		30	4.23	4.245	.9951	4.228	.9950
		120	3.55	3.558	.9951	3.549	.9950
$F_{.995}$	15	1	24600	-	-	25615.2	.9951
		2	199	572.87	.9983	285.06	.9965
		5	13.1	14.009	.9957	13.228	.9951
		15	4.07	4.082	.9951	4.070	.9950
		30	3.01	3.007	.9950	3.006	.9950
		120	2.37	2.372	.9950	2.373	.9950
$F_{.995}$	30	1	25000	-	-	25615.2	.9951
		2	199	578.74	.9983	287.53	.9965
		5	12.7	13.530	.9957	12.747	.9951
		15	3.69	3.700	.9951	3.687	.9950
		30	2.63	2.629	.9950	2.628	.9950
		120	1.98	1.984	.9950	1.984	.9950
$F_{.995}$	120	1	25400	-	-	25615.2	.9950
		2	199	583.29	.9983	289.43	.9966
		5	12.3	13.159	.9958	12.373	.9951
		15	3.37	3.387	.9951	3.373	.9950
		30	2.30	2.302	.9950	2.300	.9950
		120	1.61	1.606	.9950	1.606	.9950

* [Ref. 2: pp. 472-485]

AD-A094 568 NAVAL POSTGRADUATE SCHOOL MONTEREY CA F/G 9/2

STATISTICS PROGRAMS FOR THE TI-59 CALCULATOR.(U)

DEC 80 R W STORER

UNCLASSIFIED NL

2 OF 2

AD-A094568

END

DATE FILMED

2-81

DTIC

COMPUTER LISTINGS

PROGRAM 1 ONE-POPULATION CONFIDENCE INTERVALS

LABEL ADDRESSES

```
001  71  SBR
046  14   D
059  12   B
114  16  A'
132  13   C
164  95   =
180  33  X²
233  19  D'
266  32  X:T
282  10  E'
322  11   A
342  15   E
349  17  B'
450  18  C'
464  61  GTO
480  43  RCL
562  42  STO
```

PROGRAM LISTING

```
000  76  LBL
001  71  SBR
002  43  RCL
003  01   01
004  65   ×
005  02   2
006  85   +
007  02   2
008  54   )
009  42  STO
010  20   20
011  43  RCL
012  03   03
013  75   -
014  43  RCL
015  01   01
016  54   )
017  65   ×
018  02   2
019  54   )
020  42  STO
021  21   21
022  71  SBR
023  43  RCL
024  42  STO
025  04   04
026  43  RCL
027  21   21
028  85   +
029  02   2
030  54   )
031  48  EXC
032  20   20
033  75   -
034  02   2
035  54   )
036  42  STO
037  21   21
038  71  SBR
039  43  RCL
040  43  RCL
041  04   04
042  42  STO
043  11   11
044  92  RTN
045  76  LBL
046  14   D
047  25  CLR
048  04   4
049  69  OP
050  17   17
051  29  CP
052  47  CMS
053  91  R/S
054  78  Σ+
055  61  GTO
056  00   00
057  53   53
058  76  LBL
059  12   B
060  29  CP
061  43  RCL
062  11   11
063  22  INV
064  67   EQ
065  00   00
066  69   69
067  71  SBR
068  71  SBR
069  53   (
070  53   (
071  43  RCL
072  01   01
073  85   +
074  01   1
075  54   )
076  65   ×
077  43  RCL
078  11   11
079  55   ÷
080  53   (
081  24  CE
082  85   +
083  53   (
084  43  RCL
085  03   03
086  75   -
087  43  RCL
088  01   01
089  54   )
090  54   )
091  54   )
092  32  X:T
093  53   (
094  43  RCL
095  03   03
096  75   -
097  43  RCL
098  01   01
099  85   +
100  01   1
101  54   )
102  65   ×
103  43  RCL
104  13   13
105  55   ÷
```

PROGRAM 1 Continued

```
106  43  RCL
107  01   01
108  85   +
109  01   1
110  54   )
111  35  1/X
112  92  RTN
113  76  LBL
114  16  A'
115  71  SBR
116  95   =
117  32  X:T
118  53   (
119  71  SBR
120  95   =
121  75   -
122  53   (
123  43  RCL
124  08   08
125  65   X
126  02   2
127  54   )
128  54   )
129  94  +/-
130  92  RTN
131  76  LBL
132  13   C
133  29  CP
134  43  RCL
135  11   11
136  22  INV
137  67   EQ
138  01   01
139  49   49
140  43  RCL
141  03   03
142  75   -
143  01   1
144  54   )
145  42  STO
146  19   19
147  71  SBR
148  42  STO
149  43  RCL
150  07   07
151  22  INV
152  67   EQ
153  16  A'
154  79   X̄
155  42  STO
156  08   08
157  22  INV
158  79   X̄
159  42  STO
160  07   07
161  16  A'
162  92  RTN
163  76  LBL
164  95   =
165  43  RCL
166  07   07
167  65   X
168  43  RCL
169  11   11
170  55   ÷
171  43  RCL
172  03   03
173  34  √X
174  85   +
175  43  RCL
176  08   08
177  54   )
178  92  RTN
179  76  LBL
180  33  X²
181  17  B'
182  43  RCL
183  14   14
184  65   X
185  09   9
186  54   )
187  35  1/X
188  65   X
189  02   2
190  54   )
191  42  STO
192  15   15
193  34  √X
194  65   X
195  43  RCL
196  11   11
197  54   )
198  42  STO
199  13   13
200  94  +/-
201  85   +
202  01   1
203  75   -
204  43  RCL
205  15   15
206  54   )
207  45  YX
208  03   3
209  65   X
210  43  RCL
211  14   14
212  54   )
213  42  STO
214  11   11
215  43  RCL
216  13   13
217  85   +
218  01   1
219  75   -
220  43  RCL
221  15   15
222  54   )
223  45  YX
224  03   3
225  65   X
226  43  RCL
227  14   14
228  54   )
229  42  STO
230  13   13
231  92  RTN
232  76  LBL
233  19  D'
234  29  CP
235  43  RCL
236  12   12
237  22  INV
238  67   EQ
239  02   02
240  51   51
241  53   (
242  69  OP
243  11   11
244  65   X
245  43  RCL
246  03   03
247  54   )
248  42  STO
249  12   12
```

PROGRAM 1 Continued

```
250  29  CP
251  43  RCL
252  13   13
253  22  INV
254  67   EQ
255  32  X:T
256  43  RCL
257  03   03
258  75   -
259  01   1
260  54   )
261  42  STO
262  14   14
263  71  SBR
264  33  X²
265  76  LBL
266  32  X:T
267  43  RCL
268  12   12
269  55   ÷
270  43  RCL
271  11   11
272  54   )
273  32  X:T
274  43  RCL
275  12   12
276  55   ÷
277  43  RCL
278  13   13
279  54   )
280  92  RTN
281  76  LBL
282  10  E'
283  29  CP
284  43  RCL
285  08   08
286  22  INV
287  67   EQ
288  02   02
289  93   93
290  79   x̄
291  42  STO
292  08   08
293  43  RCL
294  08   08
295  65   ×
296  02   2
297  65   ×
298  43  RCL
299  03   03
300  54   )
301  42  STO
302  12   12
303  29  CP
304  43  RCL
305  13   13
306  22  INV
307  67   EQ
308  32  X:T
309  43  RCL
310  03   03
311  65   ×
312  02   2
313  54   )
314  42  STO
315  14   14
316  71  SBR
317  33  X²
318  71  SBR
319  32  X:T
320  92  RTN
321  76  LBL
322  11   A
323  29  CP
324  43  RCL
325  11   11
326  22  INV
327  67   EQ
328  03   03
329  31   31
330  17  B'
331  43  RCL
332  08   08
333  22  INV
334  67   EQ
335  16  A'
336  79   x̄
337  42  STO
338  08   08
339  16  A'
340  92  RTN
341  76  LBL
342  15   E
343  10  E'
344  35  1/X
345  32  X:T
346  35  1/X
347  92  RTN
348  76  LBL
349  17  B'
350  43  RCL
351  09   09
352  94  +/-
353  85   +
354  01   1
355  54   )
356  33  X²
357  23  LNX
358  94  +/-
359  34  √X
360  42  STO
361  10   10
362  53   (
363  53   (
364  53   (
365  02   2
366  93   .
367  05   5
368  01   1
369  05   5
370  05   5
371  01   1
372  07   7
373  85   +
374  93   .
375  08   8
376  00   0
377  02   2
378  08   8
379  05   5
380  03   3
381  65   ×
382  43  RCL
383  10   10
384  85   +
385  93   .
386  00   0
387  01   1
388  00   0
389  03   3
390  02   2
391  08   8
392  65   ×
393  43  RCL
```

PROGRAM 1 Continued

```
394  10   10
395  33  X²
396  54   )
397  55   ÷
398  53   (
399  01   1
400  85   +
401  01   1
402  93   .
403  04   4
404  03   3
405  02   2
406  07   7
407  08   8
408  08   8
409  65   ×
410  43  RCL
411  10   10
412  85   +
413  93   .
414  01   1
415  08   8
416  09   9
417  02   2
418  06   6
419  09   9
420  65   ×
421  43  RCL
422  10   10
423  33  X²
424  85   +
425  93   .
426  00   0
427  00   0
428  01   1
429  03   3
430  00   0
431  08   8
432  65   ×
433  43  RCL
434  10   10
435  45  Y×
436  03   3
437  54   )
438  54   )
439  75   -
440  43  RCL
441  10   10
442  54   )
443  42  STO
444  13   13
445  94  +/-
446  42  STO
447  11   11
448  92  RTN
449  76  LBL
450  18  C'
451  29  CP
452  43  RCL
453  11   11
454  22  INV
455  67   EQ
456  61  GTO
457  43  RCL
458  03   03
459  42  STO
460  14   14
461  71  SBR
462  33  X²
463  76  LBL
464  61  GTO
465  43  RCL
466  02   02
467  75   -
468  43  RCL
469  08   08
470  33  X²
471  65   ×
472  43  RCL
473  03   03
474  54   )
475  42  STO
476  12   12
477  61  GTO
478  32  X:T
479  76  LBL
480  43  RCL
481  17  B'
482  33  X²
483  75   -
484  03   3
485  54   )
486  55   ÷
487  06   6
488  54   )
489  42  STO
490  28   28
491  43  RCL
492  20   20
493  75   -
494  01   1
495  54   )
496  35  1/X
497  42  STO
498  27   27
499  85   +
500  53   (
501  43  RCL
502  21   21
503  75   -
504  01   1
505  54   )
506  35  1/X
507  22  INV
508  44  SUM
509  27   27
510  54   )
511  35  1/X
512  65   ×
513  02   2
514  54   )
515  42  STO
516  24   24
517  85   +
518  43  RCL
519  28   28
520  54   )
521  34  ΓX
522  65   ×
523  43  RCL
524  11   11
525  55   ÷
526  43  RCL
527  24   24
528  54   )
529  75   -
530  53   (
531  43  RCL
532  27   27
533  65   ×
534  53   (
535  43  RCL
536  28   28
537  85   +
```

PROGRAM 1 Continued

```
538  05  5
539  55  ÷
540  06  6
541  75  -
542  02  2
543  55  ÷
544  53  (
545  03  3
546  65  ×
547  43  RCL
548  24   24
549  54  )
550  54  )
551  54  )
552  54  )
553  65  ×
554  02  2
555  54  )
556  22  INV
557  23  LNX
558  42  STD
559  13   13
560  92  RTN
561  76  LBL
562  42  STD
563  43  RCL
564  19   19
565  53  (
566  01  1
567  94  +/-
568  85  +
569  53  (
570  01  1
571  85  +
572  01  1
573  00  0
574  55  ÷
575  53  (
576  03  3
577  65  ×
578  53  (
579  43  RCL
580  19   19
581  75  -
582  01  1
583  93  .
584  05  5
585  07  7
586  54  )
587  54  )
588  54  )
589  34  ΓX
590  54  )
591  55  ÷
592  05  5
593  54  )
594  42  STD
595  28   28
596  17  B'
597  33  X²
598  65  ×
599  43  RCL
600  28   28
601  85  +
602  01  1
603  54  )
604  49  PRD
605  11   11
606  43  RCL
607  11   11
608  92  RTN
```

END PROGRAM 1

PROGRAM 2 TWO-POPULATION CONFIDENCE INTERVALS

LABEL ADDRESSES

```
001   19  D'
026   61  GTO
084   95   =
096   13   C
158   16  A'
175   81  RST
232   17  B'
331   12   B
398   10  E'
424   15   E
457   14   D
472   71  SBR
487   52  EE
505   11   A
539   42  STO
634   43  RCL
```

PROGRAM LISTING

```
000   76  LBL
001   19  D'
002   43  RCL
003   01   01
004   42  STO
005   13   13
006   43  RCL
007   02   02
008   42  STO
009   14   14
010   43  RCL
011   03   03
012   42  STO
013   15   15
014   79   x̄
015   42  STO
016   18   18
017   22  INV
018   79   x̄
019   33  X²
020   42  STO
021   17   17
022   61  GTO
023   04   04
024   62   62
025   76  LBL
026   61  GTO
027   79   x̄
028   42  STO
029   08   08
030   22  INV
031   79   x̄
032   33  X²
033   42  STO
034   07   07
035   43  RCL
036   13   13
037   42  STO
038   04   04
039   43  RCL
040   14   14
041   42  STO
042   05   05
043   43  RCL
044   15   15
045   75   -
046   01   1
047   54   )
048   65   ×
049   43  RCL
050   17   17
051   85   +
052   53   (
053   53   (
054   43  RCL
055   03   03
056   75   -
057   01   1
058   54   )
059   65   ×
060   43  RCL
061   07   07
062   54   )
063   54   )
064   55   ÷
065   53   (
066   43  RCL
067   15   15
068   85   +
069   43  RCL
070   03   03
071   75   -
072   02   2
073   54   )
074   42  STO
075   19   19
076   54   )
077   34  ΓX
078   42  STO
079   23   23
080   43  RCL
081   19   19
082   92  RTN
083   76  LBL
084   95   =
085   43  RCL
086   12   12
087   65   ×
088   43  RCL
089   11   11
090   85   +
091   43  RCL
092   10   10
093   54   )
094   92  RTN
095   76  LBL
096   13   C
097   29  CP
098   43  RCL
099   10   10
100   67  EQ
101   01   01
102   27   27
103   43  RCL
104   15   15
105   67  EQ
106   01   01
107   50   50
108   43  RCL
109   16   16
110   67  EQ
111   01   01
112   35   35
113   85   +
114   43  RCL
115   26   26
116   54   )
117   55   ÷
118   43  RCL
119   19   19
120   54   )
121   34  ΓX
```

PROGRAM 2 Continued

122	42	STO
123	23	23
124	61	GTO
125	01	01
126	35	35
127	43	RCL
128	18	18
129	75	-
130	43	RCL
131	08	08
132	54	)
133	42	STO
134	10	10
135	43	RCL
136	15	15
137	35	1/X
138	85	+
139	43	RCL
140	03	03
141	35	1/X
142	54	)
143	34	√X
144	65	×
145	43	RCL
146	23	23
147	54	)
148	42	STO
149	12	12
150	43	RCL
151	11	11
152	22	INV
153	67	EQ
154	16	A'
155	71	SBR
156	43	RCL
157	76	LBL
158	16	A'
159	71	SBR
160	95	=
161	32	X:T
162	71	SBR
163	95	=
164	75	-
165	53	(
166	43	RCL
167	10	10
168	65	×
169	02	2
170	54	)
171	54	)
172	94	+/-
173	92	RTN
174	76	LBL
175	81	RST
176	43	RCL
177	04	04
178	75	-
179	43	RCL
180	01	01
181	54	)
182	55	÷
183	43	RCL
184	03	03
185	54	)
186	42	STO
187	10	10
188	43	RCL
189	05	05
190	85	+
191	43	RCL
192	02	02
193	75	-
194	02	2
195	65	×
196	43	RCL
197	06	06
198	54	)
199	54	)
200	75	-
201	43	RCL
202	03	03
203	65	×
204	43	RCL
205	10	10
206	33	X²
207	54	)
208	55	÷
209	43	RCL
210	03	03
211	54	)
212	34	√X
213	42	STO
214	23	23
215	55	÷
216	53	(
217	43	RCL
218	03	03
219	75	-
220	01	1
221	54	)
222	42	STO
223	19	19
224	34	√X
225	54	)
226	42	STO
227	12	12
228	43	RCL
229	19	19
230	92	RTN
231	76	LBL
232	17	B'
233	43	RCL
234	09	09
235	94	+/-
236	85	+
237	01	1
238	54	)
239	33	X²
240	23	LNX
241	94	+/-
242	34	√X
243	42	STO
244	29	29
245	53	(
246	53	(
247	53	(
248	02	2
249	93	.
250	05	5
251	01	1
252	05	5
253	05	5
254	01	1
255	07	7
256	85	+
257	93	.
258	08	8
259	00	0
260	02	2
261	08	8
262	05	5
263	03	3
264	65	×
265	43	RCL

PROGRAM 2 Continued

```
266  29   29
267  85   +
268  93   .
269  00   0
270  01   1
271  00   0
272  03   3
273  02   2
274  08   8
275  65   ×
276  43  RCL
277  29   29
278  33  X²
279  54   )
280  55   ÷
281  53   (
282  01   1
283  85   +
284  01   1
285  93   .
286  04   4
287  03   3
288  02   2
289  07   7
290  08   8
291  08   8
292  65   ×
293  43  RCL
294  29   29
295  85   +
296  93   .
297  01   1
298  08   8
299  09   9
300  02   2
301  06   6
302  09   9
303  65   ×
304  43  RCL
305  29   29
306  33  X²
307  85   +
308  93   .
309  00   0
310  00   0
311  01   1
312  03   3
313  00   0
314  08   8
315  65   ×
316  43  RCL
317  29   29
318  45  Yˣ
319  03   3
320  54   )
321  54   )
322  94  +/-
323  85   +
324  43  RCL
325  29   29
326  54   )
327  42  STO
328  11   11
329  92  RTN
330  76  LBL
331  12   B
332  29  CP
333  43  RCL
334  11   11
335  22  INV
336  67   EQ
337  03   03
338  40   40
339  17  B'
340  43  RCL
341  01   01
342  55   ÷
343  43  RCL
344  03   03
345  54   )
346  42  STO
347  18   18
348  94  +/-
349  85   +
350  01   1
351  54   )
352  65   ×
353  43  RCL
354  18   18
355  55   ÷
356  43  RCL
357  03   03
358  54   )
359  42  STO
360  05   05
361  43  RCL
362  02   02
363  55   ÷
364  43  RCL
365  04   04
366  54   )
367  42  STO
368  08   08
369  94  +/-
370  85   +
371  01   1
372  54   )
373  65   ×
374  43  RCL
375  08   08
376  55   ÷
377  43  RCL
378  04   04
379  54   )
380  85   +
381  43  RCL
382  05   05
383  54   )
384  34  √x
385  42  STO
386  12   12
387  43  RCL
388  18   18
389  75   -
390  43  RCL
391  08   08
392  54   )
393  42  STO
394  10   10
395  16  A'
396  92  RTN
397  76  LBL
398  10  E'
399  43  RCL
400  08   08
401  42  STO
402  17   17
403  43  RCL
404  18   18
405  42  STO
406  07   07
407  43  RCL
408  08   08
409  29  CP
```

PROGRAM 2 Continued

```
410  43  RCL
411  11   11
412  22  INV
413  67   EQ
414  04   04
415  36   36
416  71  SBR
417  52  EE
418  71  SBR
419  42  STO
420  61  GTO
421  04   04
422  36   36
423  76  LBL
424  15   E
425  29  CP
426  43  RCL
427  11   11
428  22  INV
429  67   EQ
430  04   04
431  36   36
432  71  SBR
433  71  SBR
434  71  SBR
435  42  STO
436  43  RCL
437  13   13
438  65   ×
439  43  RCL
440  17   17
441  55   ÷
442  43  RCL
443  07   07
444  54   )
445  32  X:T
446  43  RCL
447  17   17
448  55   ÷
449  43  RCL
450  07   07
451  55   ÷
452  43  RCL
453  11   11
454  54   )
455  92  RTN
456  76  LBL
457  14   D
458  03   3
459  69  OP
460  17   17
461  47  CMS
462  36  PGM
463  01   01
464  71  SBR
465  25  CLR
466  91  R/S
467  78  Σ+
468  61  GTO
469  04   04
470  66   66
471  76  LBL
472  71  SBR
473  43  RCL
474  03   03
475  75   -
476  01   1
477  54   )
478  42  STO
479  21   21
480  75   -
481  01   1
482  54   )
483  42  STO
484  20   20
485  92  RTN
486  76  LBL
487  52  EE
488  43  RCL
489  03   03
490  65   ×
491  02   2
492  54   )
493  42  STO
494  21   21
495  32  X:T
496  43  RCL
497  15   15
498  65   ×
499  02   2
500  54   )
501  42  STO
502  20   20
503  92  RTN
504  76  LBL
505  11   A
506  29  CP
507  43  RCL
508  11   11
509  22  INV
510  67   EQ
511  05   05
512  14   14
513  17  B'
514  43  RCL
515  12   12
516  22  INV
517  67   EQ
518  16  A'
519  43  RCL
520  17   17
521  85   +
522  43  RCL
523  07   07
524  54   )
525  34  √X
526  42  STO
527  12   12
528  43  RCL
529  18   18
530  75   -
531  43  RCL
532  08   08
533  54   )
534  42  STO
535  10   10
536  16  A'
537  92  RTN
538  76  LBL
539  42  STO
540  17  B'
541  33  X²
542  75   -
543  03   3
544  54   )
545  55   ÷
546  06   6
547  54   )
548  42  STO
549  28   28
550  43  RCL
551  20   20
552  75   -
553  01   1
```

PROGRAM 2 Continued

```
554  54  )
555  35  1/X
556  42  STO
557  27   27
558  85   +
559  53   (
560  43  RCL
561  21   21
562  75   -
563  01   1
564  54   )
565  35  1/X
566  22  INV
567  44  SUM
568  27   27
569  54   )
570  35  1/X
571  65   X
572  02   2
573  54   )
574  42  STO
575  24   24
576  85   +
577  43  RCL
578  28   28
579  54   )
580  34  ΓX
581  65   X
582  43  RCL
583  11   11
584  55   ÷
585  43  RCL
586  24   24
587  54   )
588  42  STO
589  11   11
590  75   -
591  53   (
592  43  RCL
593  27   27
594  65   X
595  53   (
596  43  RCL
597  28   28
598  85   +
599  05   5
600  55   ÷
601  06   6
602  75   -
603  02   2
604  55   ÷
605  53   (
606  03   3
607  65   X
608  43  RCL
609  24   24
610  54   )
611  54   )
612  54   )
613  44  SUM
614  11   11
615  54   )
616  65   X
617  02   2
618  54   )
619  22  INV
620  23  LNX
621  48  EXC
622  11   11
623  65   X
624  02   2
625  54   )
626  22  INV
627  23  LNX
628  42  STO
629  13   13
630  43  RCL
631  11   11
632  92  RTN
633  76  LBL
634  43  RCL
635  43  RCL
636  19   19
637  53   (
638  01   1
639  94  +/-
640  85   +
641  53   (
642  01   1
643  85   +
644  01   1
645  00   0
646  55   ÷
647  53   (
648  03   3
649  65   X
650  53   (
651  43  RCL
652  19   19
653  75   -
654  01   1
655  93   .
656  05   5
657  07   7
658  54   )
659  54   )
660  54   )
661  34  ΓX
662  54   )
663  55   ÷
664  05   5
665  54   )
666  42  STO
667  28   28
668  17  B'
669  33  X²
670  65   X
671  43  RCL
672  28   28
673  85   +
674  01   1
675  54   )
676  49  PRD
677  11   11
678  43  RCL
679  11   11
680  92  RTN
```

END PROGRAM 2

PROGRAM 3 ONE-POPULATION HYPOTHESIS TESTS

LABEL ADDRESSES

```
001  14   D
007  10  E'
025  18  C'
053  65   ×
071  55   ÷
086  30  TAN
106  25  CLR
124  38  SIN
137  39  COS
146  22  INV
150  80  GRD
159  15   E
194  12   B
229  23  LNX
263  44  SUM
286  24  CE
306  13   C
375  85   +
400  75   -
417  16  A'
452  11   A
484  57  ENG
501  17  B'
530  58  FIX
546  59  INT
569  28  LOG
596  19  D'
```

PROGRAM LISTING

```
000  76  LBL
001  14   D
002  91  R/S
003  78  Σ+
004  61  GTO
005  14   D
006  76  LBL
007  10  E'
008  25  CLR
009  03   3
010  69  OP
011  17   17
012  47  CMS
013  29  CP
014  91  R/S
015  42  STO
016  08   08
017  91  R/S
018  42  STO
019  11   11
020  91  R/S
021  42  STO
022  00   00
023  92  RTN
024  76  LBL
025  18  C'
026  06   6
027  05   5
028  32  X:T
029  43  RCL
030  06   06
031  77   GE
032  30  TAN
033  43  RCL
034  00   00
035  32  X:T
036  01   1
037  67   EQ
038  65   ×
039  94  +/-
040  67   EQ
041  55   ÷
042  93   .
043  05   5
044  49  PRD
045  11   11
046  71  SBR
047  65   ×
048  29  CP
049  67   EQ
050  55   ÷
051  92  RTN
052  76  LBL
053  65   ×
054  43  RCL
055  06   06
056  36  PGM
057  21   21
058  11   A
059  43  RCL
060  12   12
061  36  PGM
062  21   21
063  13   C
064  94  +/-
065  85   +
066  01   1
067  54   )
068  61  GTO
069  80  GRD
070  76  LBL
071  55   ÷
072  43  RCL
073  06   06
074  36  PGM
075  21   21
076  11   A
077  43  RCL
078  12   12
079  36  PGM
080  21   21
081  13   C
082  61  GTO
083  80  GRD
084  92  RTN
085  76  LBL
086  30  TAN
087  43  RCL
088  06   06
089  65   ×
090  02   2
091  54   )
092  34  √X
093  35  1/X
094  65   ×
095  53   (
096  43  RCL
097  12   12
098  75   -
099  43  RCL
100  06   06
101  54   )
102  54   )
103  42  STO
104  12   12
105  76  LBL
106  25  CLR
107  43  RCL
108  00   00
109  32  X:T
110  00   0
111  67   EQ
```

PROGRAM 3 Continued

112	38	SIN
113	01	1
114	67	EQ
115	39	COS
116	43	RCL
117	12	12
118	36	PGM
119	19	19
120	12	B
121	61	GTO
122	80	GRD
123	76	LBL
124	38	SIN
125	43	RCL
126	12	12
127	36	PGM
128	19	19
129	14	D
130	94	+/-
131	85	+
132	01	1
133	54	)
134	61	GTO
135	80	GRD
136	76	LBL
137	39	COS
138	43	RCL
139	12	12
140	36	PGM
141	19	19
142	13	C
143	61	GTO
144	80	GRD
145	76	LBL
146	22	INV
147	01	1
148	92	RTN
149	76	LBL
150	80	GRD
151	32	X:T
152	43	RCL
153	11	11
154	77	GE
155	22	INV
156	00	0
157	92	RTN
158	76	LBL
159	15	E
160	43	RCL
161	10	10
162	32	X:T
163	00	0
164	22	INV
165	67	EQ
166	01	01
167	71	71
168	79	$\bar{x}$
169	42	STO
170	10	10
171	43	RCL
172	10	10
173	65	×
174	02	2
175	65	×
176	43	RCL
177	03	03
178	55	÷
179	43	RCL
180	08	08
181	54	)
182	42	STO
183	12	12
184	43	RCL
185	03	03
186	65	×
187	02	2
188	54	)
189	42	STO
190	06	06
191	61	GTO
192	18	C'
193	76	LBL
194	12	B
195	03	3
196	00	0
197	32	X:T
198	43	RCL
199	03	03
200	77	GE
201	23	LNX
202	43	RCL
203	00	00
204	32	X:T
205	01	1
206	67	EQ
207	44	SUM
208	01	1
209	94	+/-
210	67	EQ
211	24	CE
212	93	.
213	05	5
214	49	PRD
215	11	11
216	71	SBR
217	44	SUM
218	29	CP
219	67	EQ
220	24	CE
221	48	EXC
222	01	01
223	42	STO
224	12	12
225	43	RCL
226	01	01
227	92	RTN
228	76	LBL
229	23	LNX
230	43	RCL
231	08	08
232	94	+/-
233	85	+
234	01	1
235	54	)
236	65	×
237	43	RCL
238	08	08
239	65	×
240	43	RCL
241	03	03
242	54	)
243	34	√X
244	35	1/X
245	65	×
246	53	(
247	43	RCL
248	08	08
249	65	×
250	43	RCL
251	03	03
252	94	+/-
253	85	+
254	43	RCL
255	01	01

PROGRAM 3 Continued

256	54	)
257	54	)
258	42	STO
259	12	12
260	61	GTO
261	25	CLR
262	76	LBL
263	44	SUM
264	43	RCL
265	03	03
266	36	PGM
267	20	20
268	11	A
269	43	RCL
270	08	08
271	36	PGM
272	20	20
273	12	B
274	43	RCL
275	01	01
276	75	-
277	01	1
278	54	)
279	36	PGM
280	20	20
281	15	E
282	61	GTO
283	80	GRD
284	92	RTN
285	76	LBL
286	24	CE
287	43	RCL
288	03	03
289	36	PGM
290	20	20
291	11	A
292	43	RCL
293	08	08
294	36	PGM
295	20	20
296	12	B
297	43	RCL
298	01	01
299	36	PGM
300	20	20
301	14	D
302	61	GTO
303	80	GRD
304	92	RTN
305	76	LBL
306	13	C
307	43	RCL
308	10	10
309	32	X:T
310	00	0
311	22	INV
312	67	EQ
313	03	03
314	22	22
315	79	x̄
316	42	STO
317	10	10
318	22	INV
319	79	x̄
320	42	STO
321	14	14
322	43	RCL
323	10	10
324	75	-
325	43	RCL
326	08	08
327	54	)
328	65	×
329	43	RCL
330	03	03
331	34	√X
332	55	÷
333	43	RCL
334	14	14
335	54	)
336	42	STO
337	12	12
338	03	3
339	01	1
340	32	X:T
341	43	RCL
342	03	03
343	77	GE
344	25	CLR
345	43	RCL
346	00	00
347	32	X:T
348	00	0
349	67	EQ
350	85	+
351	01	1
352	94	+/-
353	67	EQ
354	75	-
355	43	RCL
356	03	03
357	75	-
358	01	1
359	54	)
360	36	PGM
361	21	21
362	11	A
363	43	RCL
364	12	12
365	36	PGM
366	21	21
367	15	E
368	94	+/-
369	85	+
370	01	1
371	54	)
372	61	GTO
373	80	GRD
374	76	LBL
375	85	+
376	43	RCL
377	03	03
378	75	-
379	01	1
380	54	)
381	36	PGM
382	21	21
383	11	A
384	43	RCL
385	12	12
386	50	I×I
387	36	PGM
388	21	21
389	15	E
390	94	+/-
391	85	+
392	01	1
393	54	)
394	65	×
395	02	2
396	54	)
397	61	GTO
398	80	GRD
399	76	LBL

PROGRAM 3 Continued

```
400  75   -
401  43  RCL
402  03   03
403  75   -
404  01   1
405  54   )
406  36  PGM
407  21   21
408  11   A
409  43  RCL
410  12   12
411  36  PGM
412  21   21
413  15   E
414  61  GTO
415  80  GRD
416  76  LBL
417  16  A'
418  43  RCL
419  10   10
420  32  X:T
421  00   0
422  22  INV
423  67   EQ
424  04   04
425  34   34
426  69  OP
427  11   11
428  65   ×
429  43  RCL
430  03   03
431  54   )
432  42  STO
433  10   10
434  43  RCL
435  10   10
436  55   ÷
437  43  RCL
438  08   08
439  54   )
440  42  STO
441  12   12
442  43  RCL
443  03   03
444  75   -
445  01   1
446  54   )
447  42  STO
448  06   06
449  61  GTO
450  18  C'
451  76  LBL
452  11   A
453  43  RCL
454  10   10
455  32  X:T
456  00   0
457  22  INV
458  67   EQ
459  04   04
460  64   64
461  79   x̄
462  42  STO
463  10   10
464  43  RCL
465  10   10
466  75   -
467  43  RCL
468  08   08
469  54   )
470  65   ×
471  43  RCL
472  03   03
473  34  √x
474  55   ÷
475  43  RCL
476  07   07
477  54   )
478  54   )
479  42  STO
480  12   12
481  61  GTO
482  25  CLR
483  76  LBL
484  57  ENG
485  65   ×
486  02   2
487  54   )
488  36  PGM
489  21   21
490  11   A
491  43  RCL
492  02   02
493  65   ×
494  02   2
495  54   )
496  36  PGM
497  21   21
498  13   C
499  92  RTN
500  76  LBL
501  17  B'
502  03   3
503  00   0
504  32  X:T
505  43  RCL
506  01   01
507  77   GE
508  28  LOG
509  43  RCL
510  00   00
511  32  X:T
512  01   1
513  67   EQ
514  58  FIX
515  01   1
516  94  +/-
517  67   EQ
518  59  INT
519  93   .
520  05   5
521  49  PRD
522  11   11
523  71  SBR
524  58  FIX
525  29  CP
526  67   EQ
527  59  INT
528  92  RTN
529  76  LBL
530  58  FIX
531  43  RCL
532  03   03
533  65   ×
534  43  RCL
535  08   08
536  54   )
537  42  STO
538  02   02
539  43  RCL
540  01   01
541  71  SBR
542  57  ENG
543  61  GTO
```

PROGRAM 3 Continued

```
544  80  GRD
545  76  LBL
546  59  INT
547  43  RCL
548  03   03
549  65   ×
550  43  RCL
551  08   08
552  54   )
553  42  STO
554  02   02
555  43  RCL
556  01   01
557  85   +
558  01   1
559  54   )
560  71  SBR
561  57  ENG
562  94  +/-
563  85   +
564  01   1
565  54   )
566  61  GTO
567  80  GRD
568  76  LBL
569  28  LOG
570  43  RCL
571  08   08
572  65   ×
573  43  RCL
574  03   03
575  54   )
576  34  √X
577  35  1/X
578  65   ×
579  53   (
580  43  RCL
581  08   08
582  65   ×
583  43  RCL
584  03   03
585  94  +/-
586  85   +
587  43  RCL
588  01   01
589  54   )
590  54   )
591  42  STO
592  12   12
593  61  GTO
594  25  CLR
595  76  LBL
596  19  D'
597  43  RCL
598  02   02
599  85   +
600  53   (
601  43  RCL
602  10   10
603  33  X²
604  65   ×
605  43  RCL
606  03   03
607  54   )
608  75   -
609  53   (
610  02   2
611  65   ×
612  43  RCL
613  10   10
614  65   ×
615  43  RCL
616  01   01
617  54   )
618  54   )
619  55   ÷
620  43  RCL
621  08   08
622  54   )
623  42  STO
624  12   12
625  43  RCL
626  03   03
627  42  STO
628  06   06
629  71  SBR
630  18  C'
631  92  RTN
632  00   0
633  10  E'
```

END PROGRAM 3

PROGRAM 4 TWO-POPULATION HYPOTHESIS TESTS

LABEL ADDRESSES

002	61	GTO
031	33	X^2
050	10	E'
066	48	EXC
087	42	STO
093	43	RCL
100	80	GRD
113	22	INV
117	25	CLR
135	38	SIN
148	39	COS
157	60	DEG
190	85	+
207	75	-
216	17	B'
232	13	C
318	19	D'
357	15	E
396	12	B
458	81	RST
483	18	C'
567	16	A'
596	11	A
627	14	D

PROGRAM LISTING

000	92	RTN
001	76	LBL
002	61	GTO
003	43	RCL
004	01	01
005	42	STO
006	27	27
007	43	RCL
008	02	02
009	42	STO
010	26	26
011	43	RCL
012	03	03
013	42	STO
014	15	15
015	42	STO
016	28	28
017	79	$\bar{x}$
018	42	STO
019	14	14
020	22	INV
021	79	$\bar{x}$
022	33	X^2
023	42	STO
024	09	09
025	86	STF
026	02	02
027	61	GTO
028	06	06
029	45	45
030	76	LBL
031	33	X^2
032	79	$\bar{x}$
033	42	STO
034	08	08
035	22	INV
036	79	$\bar{x}$
037	33	X^2
038	42	STO
039	07	07
040	43	RCL
041	27	27
042	42	STO
043	04	04
044	43	RCL
045	26	26
046	42	STO
047	05	05
048	92	RTN
049	76	LBL
050	10	E'
051	03	3
052	69	OP
053	17	17
054	47	CMS
055	29	CP
056	25	CLR
057	91	R/S
058	42	STO
059	11	11
060	91	R/S
061	42	STO
062	00	00
063	81	RST
064	92	RTN
065	76	LBL
066	48	EXC
067	43	RCL
068	00	00
069	32	X:T
070	01	1
071	67	EQ
072	42	STO
073	94	+/-
074	67	EQ
075	43	RCL
076	93	.
077	05	5
078	49	PRD
079	11	11
080	71	SBR
081	42	STO
082	29	CP
083	67	EQ
084	43	RCL
085	92	RTN
086	76	LBL
087	42	STO
088	43	RCL
089	26	26
090	61	GTO
091	80	GRD
092	76	LBL
093	43	RCL
094	01	1
095	75	-
096	43	RCL
097	26	26
098	54	)
099	76	LBL
100	80	GRD
101	32	X:T
102	43	RCL
103	28	28
104	42	STO
105	15	15
106	43	RCL
107	11	11
108	77	GE
109	22	INV
110	00	0
111	92	RTN
112	76	LBL
113	22	INV
114	01	1

PROGRAM 4 Continued

```
115  92  RTN
116  76  LBL
117  25  CLR
118  43  RCL
119  00  00
120  32  X:T
121  00  0
122  67  EQ
123  38  SIN
124  01  1
125  67  EQ
126  39  COS
127  43  RCL
128  10  10
129  36  PGM
130  19  19
131  12  B
132  61  GTO
133  80  GRD
134  76  LBL
135  38  SIN
136  43  RCL
137  10  10
138  36  PGM
139  19  19
140  14  D
141  94  +/-
142  85  +
143  01  1
144  54  )
145  61  GTO
146  80  GRD
147  76  LBL
148  39  COS
149  43  RCL
150  10  10
151  36  PGM
152  19  19
153  13  C
154  61  GTO
155  80  GRD
156  76  LBL
157  60  DEG
158  03  3
159  00  0
160  32  X:T
161  43  RCL
162  25  25
163  77  GE
164  25  CLR
165  36  PGM
166  21  21
167  11  A
168  43  RCL
169  00  00
170  32  X:T
171  00  0
172  67  EQ
173  85  +
174  01  1
175  94  +/-
176  67  EQ
177  75  -
178  43  RCL
179  10  10
180  36  PGM
181  21  21
182  15  E
183  94  +/-
184  85  +
185  01  1
186  54  )
187  61  GTO
188  80  GRD
189  76  LBL
190  85  +
191  43  RCL
192  10  10
193  50  I×I
194  36  PGM
195  21  21
196  15  E
197  94  +/-
198  85  +
199  01  1
200  54  )
201  65  ×
202  02  2
203  54  )
204  61  GTO
205  80  GRD
206  76  LBL
207  75  -
208  43  RCL
209  10  10
210  36  PGM
211  21  21
212  15  E
213  61  GTO
214  80  GRD
215  76  LBL
216  17  B'
217  43  RCL
218  10  10
219  32  X:T
220  00  0
221  22  INV
222  67  EQ
223  60  DEG
224  36  PGM
225  13  13
226  11  A
227  42  STO
228  10  10
229  61  GTO
230  60  DEG
231  76  LBL
232  13  C
233  43  RCL
234  02  02
235  32  X:T
236  00  0
237  22  INV
238  67  EQ
239  03  03
240  06  06
241  43  RCL
242  15  15
243  42  STO
244  28  28
245  85  +
246  43  RCL
247  03  03
248  75  -
249  02  2
250  54  )
251  42  STO
252  25  25
253  35  1/X
254  65  ×
255  53  (
256  43  RCL
257  09  09
258  65  ×
```

PROGRAM 4 Continued

```
259  53   (
260  43  RCL
261  15   15
262  75   -
263  01   1
264  54   )
265  85   +
266  43  RCL
267  07   07
268  65   ×
269  53   (
270  43  RCL
271  03   03
272  75   -
273  01   1
274  54   )
275  54   )
276  54   )
277  34  ΓX
278  42  STO
279  29   29
280  65   ×
281  53   (
282  43  RCL
283  15   15
284  35  1/X
285  85   +
286  43  RCL
287  03   03
288  35  1/X
289  54   )
290  34  ΓX
291  54   )
292  35  1/X
293  65   ×
294  53   (
295  43  RCL
296  14   14
297  75   -
298  43  RCL
299  08   08
300  54   )
301  54   )
302  42  STO
303  10   10
304  61  GTO
305  60  DEG
306  36  PGM
307  13   13
308  16  A'
309  42  STO
310  10   10
311  43  RCL
312  23   23
313  42  STO
314  29   29
315  61  GTO
316  60  DEG
317  76  LBL
318  19  D'
319  43  RCL
320  15   15
321  42  STO
322  28   28
323  75   -
324  01   1
325  54   )
326  42  STO
327  15   15
328  36  PGM
329  22   22
330  11   A
331  43  RCL
332  03   03
333  75   -
334  01   1
335  54   )
336  42  STO
337  16   16
338  36  PGM
339  22   22
340  12   B
341  43  RCL
342  09   09
343  55   ÷
344  43  RCL
345  07   07
346  54   )
347  42  STO
348  10   10
349  36  PGM
350  22   22
351  13   C
352  42  STO
353  26   26
354  61  GTO
355  48  EXC
356  76  LBL
357  15   E
358  43  RCL
359  15   15
360  42  STO
361  28   28
362  65   ×
363  02   2
364  54   )
365  42  STO
366  15   15
367  36  PGM
368  22   22
369  11   A
370  43  RCL
371  03   03
372  65   ×
373  02   2
374  54   )
375  42  STO
376  16   16
377  36  PGM
378  22   22
379  12   B
380  43  RCL
381  14   14
382  55   ÷
383  43  RCL
384  08   08
385  54   )
386  42  STO
387  10   10
388  36  PGM
389  22   22
390  13   C
391  42  STO
392  26   26
393  61  GTO
394  48  EXC
395  76  LBL
396  12   B
397  43  RCL
398  01   01
399  85   +
400  43  RCL
401  04   04
402  54   )
```

PROGRAM 4 Continued

403	55	÷
404	53	(
405	43	RCL
406	15	15
407	85	+
408	43	RCL
409	03	03
410	54	)
411	54	)
412	42	STO
413	18	18
414	94	+/-
415	85	+
416	01	1
417	54	)
418	65	×
419	43	RCL
420	18	18
421	65	×
422	53	(
423	43	RCL
424	15	15
425	35	1/X
426	85	+
427	43	RCL
428	03	03
429	35	1/X
430	54	)
431	54	)
432	34	√X
433	42	STO
434	29	29
435	35	1/X
436	65	×
437	53	(
438	43	RCL
439	04	04
440	55	÷
441	43	RCL
442	15	15
443	75	-
444	53	(
445	43	RCL
446	01	01
447	55	÷
448	43	RCL
449	03	03
450	54	)
451	54	)
452	54	)
453	42	STO
454	10	10
455	61	GTO
456	25	CLR
457	76	LBL
458	81	RST
459	43	RCL
460	04	04
461	75	-
462	43	RCL
463	01	01
464	54	)
465	42	STO
466	12	12
467	43	RCL
468	05	05
469	85	+
470	43	RCL
471	02	02
472	75	-
473	02	2
474	65	×
475	43	RCL
476	06	06
477	54	)
478	42	STO
479	13	13
480	92	RTN
481	00	0
482	76	LBL
483	18	C'
484	43	RCL
485	15	15
486	42	STO
487	28	28
488	43	RCL
489	09	09
490	55	÷
491	43	RCL
492	15	15
493	54	)
494	42	STO
495	12	12
496	85	+
497	53	(
498	43	RCL
499	07	07
500	55	÷
501	43	RCL
502	03	03
503	54	)
504	42	STO
505	13	13
506	54	)
507	34	√X
508	42	STO
509	29	29
510	35	1/X
511	65	×
512	53	(
513	43	RCL
514	14	14
515	75	-
516	43	RCL
517	08	08
518	54	)
519	54	)
520	42	STO
521	10	10
522	43	RCL
523	12	12
524	33	X^2
525	55	÷
526	53	(
527	43	RCL
528	15	15
529	85	+
530	01	1
531	54	)
532	85	+
533	53	(
534	53	(
535	43	RCL
536	13	13
537	33	X^2
538	55	÷
539	53	(
540	43	RCL
541	03	03
542	85	+
543	01	1
544	54	)
545	54	)
546	54	)

PROGRAM 4 Continued

547	54	)
548	35	1/X
549	65	×
550	43	RCL
551	29	29
552	33	X^2
553	33	X^2
554	54	)
555	75	-
556	01	1
557	93	.
558	05	5
559	54	)
560	59	INT
561	42	STO
562	25	25
563	71	SBR
564	60	DEG
565	92	RTN
566	76	LBL
567	16	A'
568	43	RCL
569	03	03
570	75	-
571	02	2
572	54	)
573	42	STO
574	25	25
575	55	÷
576	53	(
577	69	OP
578	13	13
579	33	X^2
580	94	+/-
581	85	+
582	01	1
583	54	)
584	54	)
585	34	$\sqrt{X}$
586	65	×
587	69	OP
588	13	13
589	54	)
590	42	STO
591	10	10
592	71	SBR
593	60	DEG
594	92	RTN
595	76	LBL
596	11	A
597	43	RCL
598	09	09
599	55	÷
600	43	RCL
601	15	15
602	85	+
603	53	(
604	43	RCL
605	07	07
606	55	÷
607	43	RCL
608	03	03
609	54	)
610	54	)
611	34	$\sqrt{X}$
612	35	1/X
613	65	×
614	53	(
615	43	RCL
616	14	14
617	75	-
618	43	RCL
619	08	08
620	54	)
621	42	STO
622	10	10
623	71	SBR
624	25	CLR
625	92	RTN
626	76	LBL
627	14	D
628	87	IFF
629	01	01
630	61	GTO
631	86	STF
632	01	01
633	87	IFF
634	02	02
635	33	X^2
636	36	PGM
637	01	01
638	71	SBR
639	25	CLR
640	91	R/S
641	78	Σ+
642	61	GTO
643	06	06
644	40	40
645	36	PGM
646	01	01
647	71	SBR
648	25	CLR
649	22	INV
650	86	STF
651	01	01
652	91	R/S
653	78	Σ+
654	61	GTO
655	06	06
656	52	52

END PROGRAM 4

PROGRAM 5 NORMAL DISTRIBUTION APPROXIMATION

LABEL ADDRESSES

001	11	A
113	12	B
132	14	D
147	15	E
160	13	C
179	10	E'
278	19	D'

PROGRAM LISTING

000	76	LBL
001	11	A
002	53	(
003	33	X²
004	22	INV
005	23	LNX
006	65	×
007	02	2
008	65	×
009	89	π
010	54	)
011	34	√X
012	35	1/X
013	92	RTN
014	53	(
015	50	I×I
016	65	×
017	93	.
018	02	2
019	03	3
020	01	1
021	06	6
022	04	4
023	01	1
024	09	9
025	85	+
026	01	1
027	54	)
028	35	1/X
029	53	(
030	42	STO
031	25	25
032	49	PRD
033	25	25
034	42	STO
035	26	26
036	65	×
037	93	.
038	03	3
039	01	1
040	09	9
041	03	3
042	08	8
043	01	1
044	05	5
045	03	3
046	75	-
047	93	.
048	03	3
049	05	5
050	06	6
051	05	5
052	06	6
053	03	3
054	07	7
055	08	8
056	02	2
057	65	×
058	43	RCL
059	25	25
060	49	PRD
061	26	26
062	85	+
063	01	1
064	93	.
065	07	7
066	08	8
067	01	1
068	04	4
069	07	7
070	07	7
071	09	9
072	03	3
073	07	7
074	65	×
075	43	RCL
076	26	26
077	75	-
078	01	1
079	93	.
080	08	8
081	02	2
082	01	1
083	02	2
084	05	5
085	05	5
086	09	9
087	07	7
088	08	8
089	65	×
090	43	RCL
091	25	25
092	49	PRD
093	26	26
094	33	X²
095	85	+
096	01	1
097	93	.
098	03	3
099	03	3
100	00	0
101	02	2
102	07	7
103	04	4
104	04	4
105	02	2
106	09	9
107	65	×
108	43	RCL
109	26	26
110	54	)
111	92	RTN
112	76	LBL
113	12	B
114	29	CP
115	77	GE
116	01	01
117	37	37
118	42	STO
119	25	25
120	11	A
121	53	(
122	24	CE
123	65	×
124	43	RCL
125	25	25
126	71	SBR
127	00	00
128	14	14
129	54	)
130	92	RTN
131	76	LBL

PROGRAM 5 Continued

132	14	D
133	29	CP
134	77	GE
135	01	01
136	18	18
137	71	SBR
138	01	01
139	18	18
140	53	(
141	94	+/-
142	85	+
143	01	1
144	54	)
145	92	RTN
146	76	LBL
147	15	E
148	71	SBR
149	01	01
150	18	18
151	53	(
152	94	+/-
153	65	×
154	02	2
155	85	+
156	01	1
157	54	)
158	92	RTN
159	76	LBL
160	13	C
161	42	STO
162	09	09
163	32	X:T
164	93	.
165	05	5
166	22	INV
167	77	GE
168	10	E'
169	32	X:T
170	94	+/-
171	85	+
172	01	1
173	54	)
174	42	STO
175	09	09
176	86	STF
177	01	01
178	76	LBL
179	10	E'
180	43	RCL
181	09	09
182	94	+/-
183	85	+
184	01	1
185	54	)
186	33	X^2
187	23	LNX
188	94	+/-
189	34	√X
190	42	STO
191	29	29
192	02	2
193	93	.
194	05	5
195	01	1
196	05	5
197	05	5
198	01	1
199	07	7
200	85	+
201	93	.
202	08	8
203	00	0
204	02	2
205	08	8
206	05	5
207	03	3
208	65	×
209	43	RCL
210	29	29
211	85	+
212	93	.
213	00	0
214	01	1
215	00	0
216	03	3
217	02	2
218	08	8
219	65	×
220	43	RCL
221	29	29
222	33	X^2
223	54	)
224	55	÷
225	53	(
226	01	1
227	85	+
228	01	1
229	93	.
230	04	4
231	03	3
232	02	2
233	07	7
234	08	8
235	08	8
236	65	×
237	43	RCL
238	29	29
239	85	+
240	93	.
241	01	1
242	08	8
243	09	9
244	02	2
245	06	6
246	09	9
247	65	×
248	43	RCL
249	29	29
250	33	X^2
251	85	+
252	93	.
253	00	0
254	00	0
255	01	1
256	03	3
257	00	0
258	08	8
259	65	×
260	43	RCL
261	29	29
262	45	Y^X
263	03	3
264	54	)
265	54	)
266	94	+/-
267	85	+
268	43	RCL
269	29	29
270	54	)
271	42	STO
272	11	11
273	87	IFF
274	01	01
275	19	D'

PROGRAM 5 Continued

```
276  92 RTN
277  76 LBL
278  19 D'
279  43 RCL
280  09  09
281  94 +/-
282  85  +
283  01  1
284  54  )
285  42 STO
286  09  09
287  22 INV
288  86 STF
289  01  01
290  43 RCL
291  11  11
292  94 +/-
293  42 STO
294  11  11
295  92 RTN
```

END PROGRAM 5

PROGRAM 6 BINOMIAL AND MULTINOMIAL APPROXIMATIONS

LABEL ADDRESSES

```
001   16  A'
010   17  B'
019   11   A
026   12   B
039   13   C
101   14   D
107   15   E
123   18  C'
169   19  D'
227   10  E'
```

PROGRAM LISTING

```
000   76  LBL
001   16  A'
002   43  RCL
003   01   01
004   65   X
005   43  RCL
006   02   02
007   54   )
008   92  RTN
009   76  LBL
010   17  B'
011   16  A'
012   65   X
013   43  RCL
014   03   03
015   54   )
016   34  ΓX
017   92  RTN
018   76  LBL
019   11   A
020   59  INT
021   50  IXI
022   42  STO
023   01   01
024   92  RTN
025   76  LBL
026   12   B
027   42  STO
028   02   02
029   94  +/-
030   85   +
031   01   1
032   54   )
033   42  STO
034   03   03
035   43  RCL
036   02   02
037   92  RTN
038   76  LBL
039   13   C
040   29  CP
041   22  INV
042   77   GE
043   01   01
044   15   15
045   32  X:T
046   42  STO
047   04   04
048   01   1
049   94  +/-
050   42  STO
051   05   05
052   43  RCL
053   03   03
054   45  YX
055   43  RCL
056   01   01
057   54   )
058   42  STO
059   06   06
060   44  SUM
061   04   04
062   01   1
063   44  SUM
064   05   05
065   43  RCL
066   05   05
067   77   GE
068   00   00
069   97   97
070   43  RCL
071   06   06
072   65   X
073   43  RCL
074   02   02
075   65   X
076   53   (
077   43  RCL
078   01   01
079   75   -
080   43  RCL
081   05   05
082   54   )
083   55   ÷
084   53   (
085   43  RCL
086   05   05
087   85   +
088   01   1
089   54   )
090   55   ÷
091   43  RCL
092   03   03
093   54   )
094   61  GTO
095   00   00
096   58   58
097   43  RCL
098   06   06
099   92  RTN
100   76  LBL
101   14   D
102   13   C
103   43  RCL
104   04   04
105   92  RTN
106   76  LBL
107   15   E
108   13   C
109   01   1
110   75   -
111   43  RCL
112   04   04
113   54   )
114   92  RTN
115   43  RCL
116   01   01
117   85   +
118   01   1
119   54   )
120   61  GTO
121   13   C
122   76  LBL
123   18  C'
124   47  CMS
125   42  STO
126   00   00
127   42  STO
128   01   01
```

PROGRAM 6 Continued

```
129  09  9
130  69  OP
131  17   17
132  01  1
133  00  0
134  42  STO
135  02   02
136  05  5
137  00  0
138  42  STO
139  03   03
140  01  1
141  44  SUM
142  06   06
143  91  R/S
144  72  ST*
145  02   02
146  44  SUM
147  04   04
148  32  X:T
149  72  ST*
150  03   03
151  44  SUM
152  05   05
153  01  1
154  44  SUM
155  02   02
156  44  SUM
157  03   03
158  44  SUM
159  08   08
160  43  RCL
161  05   05
162  32  X:T
163  43  RCL
164  04   04
165  61  GTO
166  01   01
167  43   43
168  76  LBL
169  19  D'
170  29  CP
171  43  RCL
172  08   08
173  94  +/-
174  44  SUM
175  02   02
176  44  SUM
177  03   03
178  73  RC*
179  02   02
180  45  YX
181  73  RC*
182  03   03
183  54  )
184  49  PRD
185  06   06
186  73  RC*
187  03   03
188  42  STO
189  07   07
190  10  E'
191  35  1/X
192  49  PRD
193  06   06
194  43  RCL
195  01   01
196  49  PRD
197  06   06
198  01  1
199  44  SUM
200  02   02
201  44  SUM
202  03   03
203  94  +/-
204  44  SUM
205  01   01
206  44  SUM
207  08   08
208  43  RCL
209  08   08
210  67   EQ
211  02   02
212  16   16
213  61  GTO
214  01   01
215  78   78
216  43  RCL
217  01   01
218  42  STO
219  07   07
220  10  E'
221  65   ×
222  43  RCL
223  06   06
224  54   )
225  92  RTN
226  76  LBL
227  10  E'
228  43  RCL
229  07   07
230  65   ×
231  97  DSZ
232  07   07
233  10  E'
234  01   1
235  54   )
236  92  RTN
```

END PROGRAM 6

PROGRAM 7 CHI-SQUARE DISTRIBUTION APPROXIMATIONS

LABEL ADDRESSES

001	14	D
072	11	A
100	12	B
148	13	C
179	18	C'
234	15	E
253	10	E'
355	19	D'
374	16	A'
388	17	B'

PROGRAM LISTING

000	76	LBL
001	14	D
002	43	RCL
003	15	15
004	55	÷
005	02	2
006	85	+
007	42	STO
008	20	20
009	42	STO
010	17	17
011	93	.
012	05	5
013	54	)
014	42	STO
015	21	21
016	29	CP
017	22	INV
018	59	INT
019	67	EQ
020	00	00
021	35	35
022	89	π
023	34	√X
024	55	÷
025	02	2
026	54	)
027	42	STO
028	18	18
029	01	1
030	42	STO
031	19	19
032	61	GTO
033	00	00
034	42	42
035	89	π
036	34	√X
037	42	STO
038	19	19
039	01	1
040	42	STO
041	18	18
042	43	RCL
043	20	20
044	32	X:T
045	01	1
046	77	GE
047	00	00
048	66	66
049	01	1
050	94	+/-
051	44	SUM
052	20	20
053	44	SUM
054	21	21
055	43	RCL
056	20	20
057	49	PRD
058	19	19
059	43	RCL
060	21	21
061	49	PRD
062	18	18
063	61	GTO
064	00	00
065	42	42
066	43	RCL
067	19	19
068	49	PRD
069	17	17
070	92	RTN
071	76	LBL
072	11	A
073	42	STO
074	01	01
075	14	D
076	43	RCL
077	01	01
078	55	÷
079	02	2
080	54	)
081	45	YX
082	43	RCL
083	15	15
084	55	÷
085	43	RCL
086	01	01
087	22	INV
088	23	LNX
089	54	)
090	34	√X
091	55	÷
092	43	RCL
093	01	01
094	55	÷
095	43	RCL
096	19	19
097	54	)
098	92	RTN
099	76	LBL
100	12	B
101	11	A
102	65	×
103	02	2
104	55	÷
105	43	RCL
106	15	15
107	42	STO
108	20	20
109	65	×
110	43	RCL
111	01	01
112	54	)
113	42	STO
114	23	23
115	01	1
116	42	STO
117	21	21
118	42	STO
119	22	22
120	32	X:T
121	43	RCL
122	01	01
123	55	÷
124	02	2
125	44	SUM
126	20	20

PROGRAM 7 Continued

```
127  43  RCL
128  20   20
129  54   )
130  49  PRD
131  21   21
132  43  RCL
133  21   21
134  44  SUM
135  22   22
136  43  RCL
137  22   22
138  22  INV
139  67   EQ
140  01   01
141  20   20
142  65   ×
143  43  RCL
144  23   23
145  54   )
146  92  RTN
147  76  LBL
148  13   C
149  42  STO
150  09   09
151  43  RCL
152  15   15
153  32  X⇌T
154  01   1
155  67   EQ
156  16  A'
157  02   2
158  67   EQ
159  17  B'
160  03   3
161  00   0
162  22  INV
163  77   GE
164  01   01
165  78   78
166  18  C'
167  12   B
168  94  +/-
169  85   +
170  43  RCL
171  09   09
172  85   +
173  43  RCL
174  09   09
175  54   )
176  42  STO
177  09   09
178  76  LBL
179  18  C'
180  43  RCL
181  09   09
182  15   E
183  43  RCL
184  15   15
185  65   ×
186  09   9
187  54   )
188  35  1/X
189  65   ×
190  02   2
191  54   )
192  42  STO
193  14   14
194  34  √X
195  65   ×
196  43  RCL
197  11   11
198  54   )
199  42  STO
200  13   13
201  94  +/-
202  85   +
203  01   1
204  75   -
205  43  RCL
206  14   14
207  54   )
208  45  Y^X
209  03   3
210  65   ×
211  43  RCL
212  15   15
213  54   )
214  42  STO
215  11   11
216  43  RCL
217  13   13
218  85   +
219  01   1
220  75   -
221  43  RCL
222  14   14
223  54   )
224  45  Y^X
225  03   3
226  65   ×
227  43  RCL
228  15   15
229  54   )
230  42  STO
231  13   13
232  92  RTN
233  76  LBL
234  15   E
235  42  STO
236  09   09
237  32  X⇌T
238  93   .
239  05   5
240  22  INV
241  77   GE
242  10  E'
243  32  X⇌T
244  94  +/-
245  85   +
246  01   1
247  54   )
248  42  STO
249  09   09
250  86  STF
251  01   01
252  76  LBL
253  10  E'
254  43  RCL
255  09   09
256  94  +/-
257  85   +
258  01   1
259  54   )
260  33  X²
261  23  LNX
262  94  +/-
263  34  √X
264  42  STO
265  10   10
266  53   (
267  53   (
268  53   (
269  02   2
270  93   .
```

PROGRAM 7 Continued

271	05	5
272	01	1
273	05	5
274	05	5
275	01	1
276	07	7
277	85	+
278	93	.
279	08	8
280	00	0
281	02	2
282	08	8
283	05	5
284	03	3
285	65	×
286	43	RCL
287	10	10
288	85	+
289	93	.
290	00	0
291	01	1
292	00	0
293	03	3
294	02	2
295	08	8
296	65	×
297	43	RCL
298	10	10
299	33	X²
300	54	)
301	55	÷
302	53	(
303	01	1
304	85	+
305	01	1
306	93	.
307	04	4
308	03	3
309	02	2
310	07	7
311	08	8
312	08	8
313	65	×
314	43	RCL
315	10	10
316	85	+
317	93	.
318	01	1
319	08	8
320	09	9
321	02	2
322	06	6
323	09	9
324	65	×
325	43	RCL
326	10	10
327	33	X²
328	85	+
329	93	.
330	00	0
331	00	0
332	01	1
333	03	3
334	00	0
335	08	8
336	65	×
337	43	RCL
338	10	10
339	45	Yˣ
340	03	3
341	54	)
342	54	)
343	94	+/-
344	85	+
345	43	RCL
346	10	10
347	54	)
348	42	STO
349	11	11
350	87	IFF
351	01	01
352	19	D'
353	92	RTN
354	76	LBL
355	19	D'
356	43	RCL
357	09	09
358	94	+/-
359	85	+
360	01	1
361	54	)
362	42	STO
363	09	09
364	22	INV
365	86	STF
366	01	01
367	43	RCL
368	11	11
369	94	+/-
370	42	STO
371	11	11
372	92	RTN
373	76	LBL
374	16	A'
375	43	RCL
376	09	09
377	94	+/-
378	85	+
379	01	1
380	54	)
381	55	÷
382	02	2
383	54	)
384	15	E
385	33	X²
386	92	RTN
387	76	LBL
388	17	B'
389	43	RCL
390	09	09
391	94	+/-
392	85	+
393	01	1
394	54	)
395	23	LNX
396	94	+/-
397	65	×
398	02	2
399	54	)
400	92	RTN

END PROGRAM 7

PROGRAM 8 STUDENT'S t DISTRIBUTION APPROXIMATIONS

LABEL ADDRESSES

```
001  14   D
072  11   A
109  12   B
275  15   E
369  13   C
395  17  B'
407  18  C'
454  10  E'
```

PROGRAM LISTING

```
000  76  LBL
001  14   D
002  43  RCL
003  15   15
004  55   ÷
005  02   2
006  85   +
007  42  STO
008  20   20
009  42  STO
010  17   17
011  93   .
012  05   5
013  54   )
014  42  STO
015  21   21
016  29  CP
017  22  INV
018  59  INT
019  67   EQ
020  00   00
021  35   35
022  89   π
023  34  √X
024  55   ÷
025  02   2
026  54   )
027  42  STO
028  18   18
029  01   1
030  42  STO
031  19   19
032  61  GTO
033  00   00
034  42   42
035  89   π
036  34  √X
037  42  STO
038  19   19
039  01   1
040  42  STO
041  18   18
042  43  RCL
043  20   20
044  32  X:T
045  01   1
046  77   GE
047  00   00
048  36   66
049  01   1
050  94  +/-
051  44  SUM
052  20   20
053  44  SUM
054  21   21
055  43  RCL
056  20   20
057  49  PRD
058  19   19
059  43  RCL
060  21   21
061  49  PRD
062  18   18
063  61  GTO
064  00   00
065  42   42
066  43  RCL
067  19   19
068  49  PRD
069  17   17
070  92  RTN
071  76  LBL
072  11   A
073  42  STO
074  01   01
075  14   D
076  43  RCL
077  01   01
078  33  X²
079  55   ÷
080  43  RCL
081  15   15
082  85   +
083  01   1
084  54   )
085  45  Yˣ
086  53   (
087  43  RCL
088  15   15
089  85   +
090  01   1
091  54   )
092  65   ×
093  43  RCL
094  15   15
095  65   ×
096  89   π
097  54   )
098  34  √X
099  65   ×
100  43  RCL
101  19   19
102  55   ÷
103  43  RCL
104  18   18
105  54   )
106  35  1/X
107  92  RTN
108  76  LBL
109  12   B
110  42  STO
111  01   01
112  14   D
113  43  RCL
114  01   01
115  55   ÷
116  43  RCL
117  15   15
118  34  √X
119  54   )
120  70  RAD
121  22  INV
122  30  TAN
123  42  STO
124  16   16
125  39  COS
126  42  STO
127  20   20
128  42  STO
```

PROGRAM 8 Continued

```
129  23  23
130  33  X²
131  42  STO
132  21  21
133  43  RCL
134  15  15
135  55  ÷
136  02  2
137  54  )
138  22  INV
139  59  INT
140  29  CP
141  67  EQ
142  02  02
143  16  16
144  01  1
145  32  X⇌T
146  43  RCL
147  15  15
148  67  EQ
149  02  02
150  11  11
151  43  RCL
152  15  15
153  75  -
154  02  2
155  54  )
156  32  X⇌T
157  42  STO
158  22  22
159  42  STO
160  24  24
161  67  EQ
162  01  01
163  95  95
164  43  RCL
165  21  21
166  65  ×
167  01  1
168  44  SUM
169  22  22
170  43  RCL
171  22  22
172  55  ÷
173  01  1
174  44  SUM
175  22  22
176  43  RCL
177  22  22
178  54  )
179  49  PRD
180  24  24
181  43  RCL
182  24  24
183  65  ×
184  43  RCL
185  20  20
186  54  )
187  44  SUM
188  23  23
189  43  RCL
190  22  22
191  22  INV
192  67  EQ
193  01  01
194  64  64
195  43  RCL
196  16  16
197  85  +
198  38  SIN
199  65  ×
200  43  RCL
201  23  23
202  54  )
203  65  ×
204  02  2
205  55  ÷
206  89  π
207  54  )
208  61  GTO
209  02  02
210  67  67
211  43  RCL
212  16  16
213  61  GTO
214  02  02
215  03  03
216  43  RCL
217  15  15
218  75  -
219  02  2
220  54  )
221  32  X⇌T
222  01  1
223  42  STO
224  20  20
225  42  STO
226  22  22
227  00  0
228  42  STO
229  23  23
230  43  RCL
231  23  23
232  67  EQ
233  02  02
234  60  60
235  53  (
236  43  RCL
237  21  21
238  65  ×
239  01  1
240  44  SUM
241  23  23
242  43  RCL
243  23  23
244  55  ÷
245  01  1
246  44  SUM
247  23  23
248  43  RCL
249  23  23
250  54  )
251  49  PRD
252  22  22
253  43  RCL
254  22  22
255  44  SUM
256  20  20
257  61  GTO
258  02  02
259  30  30
260  43  RCL
261  20  20
262  65  ×
263  43  RCL
264  16  16
265  38  SIN
266  54  )
267  55  ÷
268  02  2
269  85  +
270  93  .
271  05  5
272  54  )
```

PROGRAM 8 Continued

273	92	RTN
274	76	LBL
275	15	E
276	94	+/-
277	85	+
278	01	1
279	54	)
280	33	X^2
281	23	LNX
282	94	+/-
283	34	√X
284	42	STD
285	10	10
286	02	2
287	93	.
288	05	5
289	01	1
290	05	5
291	05	5
292	01	1
293	07	7
294	85	+
295	93	.
296	08	8
297	00	0
298	02	2
299	08	8
300	05	5
301	03	3
302	65	×
303	43	RCL
304	10	10
305	85	+
306	93	.
307	00	0
308	01	1
309	00	0
310	03	3
311	02	2
312	08	8
313	65	×
314	43	RCL
315	10	10
316	33	X^2
317	54	)
318	55	÷
319	53	(
320	01	1
321	85	+
322	01	1
323	93	.
324	04	4
325	03	3
326	02	2
327	07	7
328	08	8
329	08	8
330	65	×
331	43	RCL
332	10	10
333	85	+
334	93	.
335	01	1
336	08	8
337	09	9
338	02	2
339	06	6
340	09	9
341	65	×
342	43	RCL
343	10	10
344	33	X^2
345	85	+
346	93	.
347	00	0
348	00	0
349	01	1
350	03	3
351	00	0
352	08	8
353	65	×
354	43	RCL
355	10	10
356	45	Y^X
357	03	3
358	54	)
359	54	)
360	94	+/-
361	85	+
362	43	RCL
363	10	10
364	54	)
365	42	STD
366	09	09
367	92	RTN
368	76	LBL
369	13	C
370	42	STD
371	00	00
372	43	RCL
373	15	15
374	32	X:T
375	01	1
376	67	EQ
377	10	E'
378	93	.
379	05	5
380	32	X:T
381	43	RCL
382	00	00
383	77	GE
384	17	B'
385	94	+/-
386	85	+
387	01	1
388	54	)
389	42	STD
390	00	00
391	17	B'
392	94	+/-
393	92	RTN
394	76	LBL
395	17	B'
396	18	C'
397	12	B
398	94	+/-
399	48	EXC
400	00	00
401	65	×
402	02	2
403	54	)
404	44	SUM
405	00	00
406	76	LBL
407	18	C'
408	01	1
409	94	+/-
410	85	+
411	53	(
412	01	1
413	85	+
414	01	1
415	00	0
416	55	÷

PROGRAM 8 Continued

```
417   53    (
418   03    3
419   65    ×
420   53    (
421   43   RCL
422   15    15
423   75    -
424   01    1
425   93    .
426   05    5
427   07    7
428   54    )
429   54    )
430   54    )
431   34   √X
432   54    )
433   55    ÷
434   05    5
435   54    )
436   42   STO
437   02    02
438   43   RCL
439   00    00
440   15    Σ
441   33   X²
442   65    ×
443   43   RCL
444   02    02
445   85    +
446   01    1
447   54    )
448   65    ×
449   43   RCL
450   09    09
451   54    )
452   92   RTN
453   76   LBL
454   10   E'
455   93    .
456   05    5
457   32   X:T
458   43   RCL
459   00    00
460   22   INV
461   67    EQ
462   04    04
463   70    70
464   94   +/-
465   85    +
466   01    1
467   54    )
468   42   STO
469   00    00
470   65    ×
471   89    π
472   54    )
473   70   RAD
474   30   TAN
475   35   1/X
476   94   +/-
477   92   RTN
```

END PROGRAM 8

PROGRAM 9 F DISTRIBUTION APPROXIMATIONS

LABEL ADDRESSES

```
001   12   B
375   11   A
386   15   E
404   19   D'
498   13   C
526   10   E'
607   16   A'
617   17   B'
632   14   D
650   18   C'
```

PROGRAM LISTING

```
000   76   LBL
001   12   B
002   42   STO
003   17   17
004   22   INV
005   86   STF
006   01   01
007   43   RCL
008   15   15
009   55   ÷
010   02   2
011   54   )
012   22   INV
013   59   INT
014   29   CP
015   67   EQ
016   00   00
017   20   20
018   86   STF
019   01   01
020   22   INV
021   86   STF
022   02   02
023   43   RCL
024   16   16
025   55   ÷
026   02   2
027   54   )
028   22   INV
029   59   INT
030   67   EQ
031   00   00
032   35   35
033   86   STF
034   02   02
035   43   RCL
036   17   17
037   87   IFF
038   01   01
039   01   01
040   43   43
041   87   IFF
042   02   02
043   00   00
044   53   53
045   43   RCL
046   16   16
047   32   X:T
048   43   RCL
049   15   15
050   77   GE
051   01   01
052   47   47
053   43   RCL
054   15   15
055   42   STO
056   18   18
057   43   RCL
058   16   16
059   42   STO
060   19   19
061   42   STO
062   25   25
063   71   SBR
064   01   01
065   30   30
066   42   STO
067   20   20
068   94   +/-
069   42   STO
070   21   21
071   43   RCL
072   18   18
073   55   ÷
074   02   2
075   54   )
076   32   X:T
077   01   1
078   44   SUM
079   21   21
080   42   STO
081   22   22
082   42   STO
083   23   23
084   42   STO
085   24   24
086   43   RCL
087   22   22
088   77   GE
089   01   01
090   15   15
091   35   1/X
092   65   ×
093   43   RCL
094   21   21
095   65   ×
096   43   RCL
097   19   19
098   55   ÷
099   02   2
100   44   SUM
101   19   19
102   54   )
103   49   PRD
104   23   23
105   01   1
106   44   SUM
107   22   22
108   43   RCL
109   23   23
110   44   SUM
111   24   24
112   61   GTO
113   00   00
114   86   86
115   43   RCL
116   20   20
117   34   √X
118   45   Y^X
119   43   RCL
120   25   25
121   65   ×
122   43   RCL
123   24   24
124   54   )
125   94   +/-
126   85   +
```

PROGRAM 9 Continued

127	01	1
128	54	)
129	92	RTN
130	43	RCL
131	15	15
132	55	÷
133	43	RCL
134	16	16
135	65	×
136	43	RCL
137	17	17
138	85	+
139	01	1
140	54	)
141	35	1/X
142	92	RTN
143	87	IFF
144	02	02
145	01	01
146	79	79
147	43	RCL
148	16	16
149	42	STO
150	18	18
151	43	RCL
152	15	15
153	42	STO
154	19	19
155	42	STO
156	25	25
157	71	SBR
158	01	01
159	30	30
160	42	STO
161	21	21
162	94	+/-
163	42	STO
164	20	20
165	01	1
166	44	SUM
167	20	20
168	22	INV
169	44	SUM
170	21	21
171	71	SBR
172	00	00
173	71	71
174	94	+/-
175	85	+
176	01	1
177	54	)
178	92	RTN
179	65	×
180	43	RCL
181	15	15
182	55	÷
183	43	RCL
184	16	16
185	54	)
186	34	√X
187	70	RAD
188	22	INV
189	30	TAN
190	42	STO
191	17	17
192	38	SIN
193	42	STO
194	20	20
195	43	RCL
196	17	17
197	39	COS
198	42	STO
199	21	21
200	42	STO
201	22	22
202	42	STO
203	23	23
204	01	1
205	42	STO
206	24	24
207	42	STO
208	25	25
209	32	X:T
210	43	RCL
211	16	16
212	67	EQ
213	02	02
214	58	58
215	75	-
216	02	2
217	54	)
218	32	X:T
219	43	RCL
220	25	25
221	67	EQ
222	02	02
223	50	50
224	43	RCL
225	21	21
226	33	X^2
227	65	×
228	43	RCL
229	24	24
230	65	×
231	02	2
232	44	SUM
233	25	25
234	55	÷
235	43	RCL
236	25	25
237	54	)
238	49	PRD
239	23	23
240	43	RCL
241	23	23
242	44	SUM
243	22	22
244	01	1
245	44	SUM
246	24	24
247	61	GTO
248	02	02
249	19	19
250	43	RCL
251	20	20
252	49	PRD
253	22	22
254	43	RCL
255	22	22
256	44	SUM
257	17	17
258	01	1
259	42	STO
260	22	22
261	01	1
262	42	STO
263	24	24
264	32	X:T
265	43	RCL
266	15	15
267	67	EQ
268	03	03
269	60	60
270	43	RCL

PROGRAM 9 Continued

```
271  16  16
272  67  EQ
273  02  02
274  98  98
275  42  STO
276  23  23
277  01  1
278  22  INV
279  44  SUM
280  23  23
281  43  RCL
282  23  23
283  49  PRD
284  24  24
285  01  1
286  22  INV
287  44  SUM
288  23  23
289  43  RCL
290  23  23
291  22  INV
292  49  PRD
293  24  24
294  22  INV
295  67  EQ
296  02  02
297  77  77
298  43  RCL
299  21  21
300  45  YX
301  43  RCL
302  16  16
303  65  X
304  43  RCL
305  20  20
306  54  )
307  49  PRD
308  24  24
309  43  RCL
310  15  15
311  32  X:T
312  43  RCL
313  16  16
314  75  -
315  01  1
316  42  STO
317  26  26
318  42  STO
319  27  27
320  54  )
321  42  STO
322  25  25
323  02  2
324  44  SUM
325  25  25
326  44  SUM
327  26  26
328  43  RCL
329  26  26
330  77  GE
331  03  03
332  51  51
333  35  1/X
334  65  X
335  43  RCL
336  25  25
337  65  X
338  43  RCL
339  20  20
340  33  X²
341  54  )
342  49  PRD
343  27  27
344  43  RCL
345  27  27
346  44  SUM
347  22  22
348  61  GTO
349  03  03
350  23  23
351  43  RCL
352  22  22
353  65  X
354  43  RCL
355  24  24
356  54  )
357  22  INV
358  44  SUM
359  17  17
360  01  1
361  75  -
362  43  RCL
363  17  17
364  65  X
365  02  2
366  55  ÷
367  89  π
368  54  )
369  94  +/-
370  85  +
371  01  1
372  54  )
373  92  RTN
374  76  LBL
375  11  A
376  42  STO
377  16  16
378  32  X:T
379  42  STO
380  15  15
381  03  3
382  69  OP
383  17  17
384  92  RTN
385  76  LBL
386  15  E
387  42  STO
388  08  08
389  93  .
390  05  5
391  32  X:T
392  43  RCL
393  08  08
394  77  GE
395  19  D'
396  71  SBR
397  04  04
398  09  09
399  94  +/-
400  42  STO
401  11  11
402  92  RTN
403  76  LBL
404  19  D'
405  94  +/-
406  85  +
407  01  1
408  54  )
409  33  X²
410  23  LNX
411  94  +/-
412  34  √X
413  42  STO
414  29  29
```

PROGRAM 9 Continued

415	02	2
416	93	.
417	05	5
418	01	1
419	05	5
420	05	5
421	01	1
422	07	7
423	85	+
424	93	.
425	08	8
426	00	0
427	02	2
428	08	8
429	05	5
430	03	3
431	65	×
432	43	RCL
433	29	29
434	85	+
435	93	.
436	00	0
437	01	1
438	00	0
439	03	3
440	02	2
441	08	8
442	65	×
443	43	RCL
444	29	29
445	33	X^2
446	54	)
447	55	÷
448	53	(
449	01	1
450	85	+
451	01	1
452	93	.
453	04	4
454	03	3
455	02	2
456	07	7
457	08	8
458	08	8
459	65	×
460	43	RCL
461	29	29
462	85	+
463	93	.
464	01	1
465	08	8
466	09	9
467	02	2
468	06	6
469	09	9
470	65	×
471	43	RCL
472	29	29
473	33	X^2
474	85	+
475	93	.
476	00	0
477	00	0
478	01	1
479	03	3
480	00	0
481	08	8
482	65	×
483	43	RCL
484	29	29
485	45	Y^X
486	03	3
487	54	)
488	54	)
489	94	+/-
490	85	+
491	43	RCL
492	29	29
493	54	)
494	42	STO
495	11	11
496	92	RTN
497	76	LBL
498	13	C
499	42	STO
500	09	09
501	01	1
502	32	X:T
503	43	RCL
504	15	15
505	67	EQ
506	16	A'
507	43	RCL
508	16	16
509	67	EQ
510	17	B'
511	43	RCL
512	09	09
513	10	E'
514	12	B
515	94	+/-
516	85	+
517	43	RCL
518	09	09
519	85	+
520	43	RCL
521	09	09
522	54	)
523	10	E'
524	92	RTN
525	76	LBL
526	10	E'
527	15	E
528	33	X^2
529	75	-
530	03	3
531	54	)
532	55	÷
533	06	6
534	54	)
535	42	STO
536	17	17
537	43	RCL
538	15	15
539	75	-
540	01	1
541	54	)
542	35	1/X
543	42	STO
544	18	18
545	85	+
546	53	(
547	43	RCL
548	16	16
549	75	-
550	01	1
551	54	)
552	35	1/X
553	22	INV
554	44	SUM
555	18	18
556	54	)
557	35	1/X
558	65	×

PROGRAM 9 Continued

```
559  02  2
560  54  )
561  42  STO
562  19  19
563  85  +
564  43  RCL
565  17  17
566  54  )
567  34  ΓX
568  65  ×
569  43  RCL
570  11  11
571  55  ÷
572  43  RCL
573  19  19
574  54  )
575  85  +
576  53  (
577  43  RCL
578  18  18
579  65  ×
580  53  (
581  43  RCL
582  17  17
583  85  +
584  05  5
585  55  ÷
586  06  6
587  75  -
588  02  2
589  55  ÷
590  53  (
591  03  3
592  65  ×
593  43  RCL
594  19  19
595  54  )
596  54  )
597  54  )
598  94  +/-
599  54  )
600  65  ×
601  02  2
602  54  )
603  22  INV
604  23  LNX
605  92  RTN
606  76  LBL
607  16  A'
608  43  RCL
609  16  16
610  42  STO
611  15  15
612  67  EQ
613  14  D
614  18  C'
615  92  RTN
616  76  LBL
617  17  B'
618  43  RCL
619  09  09
620  94  +/-
621  85  +
622  01  1
623  54  )
624  42  STO
625  09  09
626  43  RCL
627  15  15
628  18  C'
629  35  1/X
630  92  RTN
631  76  LBL
632  14  D
633  43  RCL
634  09  09
635  94  +/-
636  85  +
637  01  1
638  54  )
639  65  ×
640  89  π
641  55  ÷
642  02  2
643  54  )
644  70  RAD
645  30  TAN
646  35  1/X
647  33  X²
648  92  RTN
649  76  LBL
650  18  C'
651  43  RCL
652  09  09
653  85  +
654  01  1
655  54  )
656  55  ÷
657  02  2
658  54  )
659  42  STO
660  00  00
661  53  (
662  01  1
663  94  +/-
664  85  +
665  53  (
666  01  1
667  85  +
668  01  1
669  00  0
670  55  ÷
671  53  (
672  03  3
673  65  ×
674  53  (
675  43  RCL
676  15  15
677  75  -
678  01  1
679  93  .
680  05  5
681  07  7
682  54  )
683  54  )
684  54  )
685  34  ΓX
686  54  )
687  55  ÷
688  05  5
689  54  )
690  42  STO
691  02  02
692  43  RCL
693  00  00
694  15  E
695  33  X²
696  65  ×
697  43  RCL
698  02  02
699  85  +
700  01  1
701  54  )
702  65  ×
```

PROGRAM 9 Continued

```
703   43 RCL
704   11  11
705   54  )
706   33 X²
707   92 RTN
```

END PROGRAM 9

LIST OF REFERENCES

1. Mood, A. M., F. A. Graybill, and D. C. Boes, Introduction to the Theory of Statistics, Third Edition, McGraw-Hill, 1974.

2. Dixon, W. J. and F. J. Massey, Introduction to Statistical Analysis, Third Edition, McGraw-Hill, 1969.

3. Larson, H. J., Introduction to Probability Theory and Statistical Inference, Second Edition, Wiley, 1974.

4. Zehna, P. W., Probability Distributions and Statistics, Allyn and Bacon, 1970.

5. Abramowitz, M. and I. Stegun, Handbook of Mathematical Functions, Dover Publications, 1968.

6. Naval Postgraduate School Report NPS55-80-004PR, Report on an Experiment on Formal Use of Hand Held Programmable Calculators in Statistics Courses, by D. R. Barr, January 1980.

7. Texas Instruments Incorporated, Applied Statistics, 1977.

8. Gaver, D. P., Recipes for Inverse "t," Naval Postgraduate School, Monterey, California, November 1980.

INITIAL DISTRIBUTION LIST

		No. Copies
1.	Defense Technical Information Center Cameron Station Alexandria, Virginia 22314	2
2.	Library, Code 0142 Naval Postgraduate School Monterey, California 93940	2
3.	Department Chairman, Code 55 Department of Operations Research Naval Postgraduate School Monterey, California 93940	1
4.	Professor D. R. Barr, Code 55Bn Department of Operations Research Naval Postgraduate School Monterey, California 93940	2
5.	Professor P. W. Zehna, Code 55Ze Department of Operations Research Naval Postgraduate School Monterey, California 93940	2
6.	Professor D. P. Gaver, Code 55Gv Department of Operations Research Naval Postgraduate School Monterey, California 93940	1
7.	LCDR C. F. Taylor, Code 55Ta Department of Operations Research Naval Postgraduate School Monterey, California 93940	1
8.	Capt Richard W. Storer, USAF Department of Mathematical Sciences (DFMS) United States Air Force Academy, Colorado 80840	2
9.	Lt Col John Kitch, Jr., USAF Chief, AFIT/CIR Wright-Patterson Air Force Base, Ohio 45433	1
10.	Capt John Thompson, USAF 3780 TTGP/TTGBF Sheppard Air Force Base, Texas 76311	1

DATE
FILMED

– 8